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Surface Coating of Plastic Parts for Business Machines--Background Information for Proposed Standards

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Standards of Performance for the control of VOC emissions from affected facilities that perform exterior surface coating of plastic parts for business machines are being proposed under authority of Section 111 of the Clean Air Act. These standards would apply to each new, modified, and reconstructed spray booth in which plastic parts for business machines are surface coated and that commence construction on or after the date of proposal of the regulation. This document contains background information and environmental and economic impact assessments of the regulatory alternatives considered in developing the proposed standards.

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ENVIRONMENTAL PROTECTION AGENCY

Background Information
and Draft
Environmental Impact Statement
for the Surface Coating of Plastic Parts for Business Machines

Prepared by:

1/10/86

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Research Triangle Park, N.C. 27711

(Date)

1. The proposed standards of performance would limit emissions of volatile organic compounds (VOC's) from new, modified, and reconstructed facilities that surface coat plastic parts for business machines. Section 111 of the Clean Air Act (42 U.S.C. 7411), as amended, directs the Administrator to establish standards of performance for any category of new stationary source of air pollution that ". . . causes or contributes significantly to air pollution which may reasonably be anticipated to endanger public health or welfare."

2. Copies of this document have been sent to the following Federal Departments: Labor, Health and Human Services, Defense, Transportation, Agriculture, Commerce, Interior, and Energy; the National Science Foundation; the Council on Environmental Quality; State and Territorial Air Pollution Program Administrators; EPA Regional Administrators; Local Air Pollution Control Officials; Office of Management and Budget; and other interested parties.

3. The comment period for review of this document is 75 days from the date of publication of the proposed standard in the Federal Register. Mr. C. Douglas Bell may be contacted at (919) 541-5578 regarding the date of the comment period.

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Emission Standards and Engineering Division

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

December 1985

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1. SUMMARY

1.1 REGULATORY ALTERNATIVES

This background information document (BID) supports proposal of the new source performance standard (NSPS) for emissions of volatile organic compounds (VOC's) from facilities that surface coat plastic parts for business machines. The development of standards of performance for new, modified, or reconstructed stationary sources of air pollution was dictated by Section 111 of the Clean Air Act (42 USC 7411), as amended.

The plastic parts coating process emits VOC's. These VOC's participate in atmospheric photochemical reactions to produce ozone and other photochemical oxidants. The photochemical oxidants cause, or contribute significantly to, air pollution which may reasonably be anticipated to endanger public health or welfare. The sources of the VOC emissions are the decorative and protective coatings used on the exterior surface of plastic parts and the metal-filled electromagnetic interference/radio-frequency interference (EMI/RFI) shielding coatings used on the interior surface of plastic parts. The VOC's used in these coatings evaporate into the atmosphere as the coating dries.

Regulatory alternatives to reduce VOC emissions were considered. The 32 alternatives were derived from combining each of four EMI/RFI shielding control options with each of eight exterior coating control options. These alternatives are presented in detail in Chapter 6. To simplify the presentation of the regulatory alternatives, the control options for EMI/RFI shielding and exterior coating are discussed separately below.

The control options for EMI/RFI shielding coatings are as follows:

1. The use of organic-solvent-based metal-filled coatings containing 15 percent, by volume, solids at the spray gun;

2. The use of organic-solvent-based metal-filled coatings containing 25 percent, by volume, solids at the spray gun;

3. The use of waterborne coatings containing 33 percent, by volume, solids at the spray gun and a VOC-to-water volume ratio of 28:72 in the coating; and

4. The use of zinc metal that has been melted in an electric arc gun and blown onto a part by a jet of compressed air flowing from the electric arc gun (zinc-arc spray).

Control option 1 for EMI/RFI shielding coatings represents the baseline, the current industry practice in absence of an NSPS. The coatings used in options 1 through 3 are applied at a transfer efficiency (TE) of 50 percent (i.e., 50 percent of the coating solids sprayed adheres to the part). The process in option 4 has a TE of 53 percent.

The control options for exterior coatings specify either a TE of 25 percent for all coats or a TE of 40 percent for the prime and color coats and 25 percent for texture and touch-up coats. The higher TE can be achieved by using air-assisted airless or electrostatic spray equipment instead of the conventional air-atomized equipment. Discussion of this equipment is presented in Chapters 3 and 4.

The control options for exterior coating are as follows:

1. The combination of coatings currently used by the coaters of plastic parts (see Chapter 6, Table 6-1) applied at 25-percent TE for all exterior steps;

2. The combination of coatings currently used by the coaters of plastic parts applied at 40-percent TE for prime and color coats and 25-percent TE for texture and touch-up coats;

3. The use of organic-solvent-based coatings containing 50 percent, by volume, solids at the spray gun applied at 25-percent TE for all exterior coats (the quantity of plastic coated with waterborne coatings remains at baseline levels);

4. The use of organic-solvent-based coatings containing 50 percent, by volume, solids at the spray gun applied at 40-percent TE for prime and color coats and 25-percent TE for texture and touch-up coats;

5. The use of organic-solvent-based coatings containing 60 percent, by volume, solids at the spray gun applied at 25-percent TE for all

exterior coats (the quantity of plastic coated with waterborne coatings remains at baseline levels);

6. The use of organic-solvent-based coatings containing 60 percent, by volume, solids at the spray gun applied at 40-percent TE for prime and color coats and 25-percent TE for texture and touch-up coats;

7. The use of waterborne coatings containing 37 percent, by volume, solids at the spray gun and a VOC-to-water volume ratio of 1:4 in the coating applied at 25-percent TE for all exterior coats; and

8. The use of waterborne coatings containing 37 percent, by volume, solids at the spray gun and a VOC-to-water volume ratio of 1:4 in the coating applied at 40-percent TE for prime and color coats and 25-percent TE for texture and touch-up coats.

Exterior control option 1 represents the baseline. The EMI/RFI control option and exterior control option used in each of the 32 regulatory alternatives is presented in Table 1-1. Regulatory alternatives with the suffix "-25" use the exterior options that require 25-percent TE for all exterior steps (options 1, 3, 5, and 7). The alternatives with the suffix "-25/40" use the exterior options that require 25-percent TE for texture and touch-up coats and 40 percent TE for prime and color coats (options 2, 4, 6, and 8).

1.2 ENVIRONMENTAL IMPACT

The beneficial and adverse environmental impacts that could result from implementation of the 32 regulatory alternatives are summarized in Table 1-2. The estimated effects in Table 1-2 were derived from the detailed analyses of environmental and energy impacts of each regulatory alternative presented in Chapter 7 relative to alternative I-25, the baseline.

The air impacts were ranked so that the alternatives with 0- to 10-percent VOC emission reduction were rated at 0, those with reductions between 11 and 15 percent were rated at +1, those between 16 and 35 percent were rated at +2, those between 36 and 70 percent were rated at +3, and those with greater than 70 percent emission reduction were rated at +4.

Water quality is not expected to be affected adversely by any of the first 16 alternatives in Table 1-1 (the "-25" alternatives) and is slightly improved by the second 16 alternatives (the "-25/40" alternatives) because the coating overspray is reduced by the improved transfer efficiency. The amount of solid waste generated would be slightly less for all the alternatives that use zinc-arc spray as the EMI/RFI shielding option compared to the amount for the alternatives that use metal-filled coatings because the oversprayed zinc can be recovered and resold. The "-25/40" alternatives produce a solid waste impact that is more beneficial than the "-25" alternatives because of the reduced volume of coating overspray.

Regulatory alternatives that use either waterborne exterior coatings (for EMI/RFI shielding or exterior coating) or zinc-arc spray would increase negligibly the energy required for the coating process. Compared to organic-solvent-based coatings, waterborne coatings may require additional time in an oven to speed up the drying process. Zinc-arc spraying requires the use of an electric arc spray gun to melt and spray the zinc wire. The zinc-arc spraying process is also noisy; therefore, in-plant noise levels will be higher for alternatives using zinc-arc spray.

1.3 ECONOMIC IMPACT

The economic impacts of each of the regulatory alternatives are presented in Table 1-2. The economic impact ratings in Table 1-2 are based on the total cost for the plastic parts coating industry presented in Chapter 9, Table 9-15. According to Table 9-15, regulatory alternative VIII-25/40 is the most economically beneficial. For regulatory alternative VIII-25/40, it is estimated in Table 9-7 that the capital cost of a new facility will increase from the current, or baseline, cost of $42,000 to $53,000 for small plants, from $476,000 to $497,000 for medium plants, and from $956,000 to $992,000 for large plants. However, according to Tables 8-7, 8-8, and 8-9, the annualized costs to each of the three types of plants are expected to decrease. The annualized cost should drop from the baseline cost of $434,000 to $327,000 for small plants, from $2,665,000 to $2,327,000 for medium plants, and from $5,667,000 to $4,983,000 for large plants.

TABLE 1-1. CONTROL OPTIONS USED IN THE REGULATORY ALTERNATIVES

Coating control option	Regulatory Alternatives															
	I-25 and I-25/40[a]	II-25 and II-25/40	III-25 and III-25/40	IV-25 and IV-25/40	V-25 and V-25/40	VI-25 and VI-25/40	VII-25 and VII-25/40	VIII-25 and VIII-25/40	IX-25 and IX-25/40	X-25 and X-25/40	XI-25 and XI-25/40	XII-25 and XII-25/40	XIII-25 and XIII-25/40	XIV-25 and XIV-25/40	XV-25 and XV-25/40	XVI-25 and XVI-25/40
EMI/RFI SHIELDING																
1	X				X			X				X				
2		X				X				X				X		
3			X				X				X				X	
4				X					X				X			X
EXTERIOR																
1 and 2	X	X	X	X												
3 and 4					X	X	X		X							
5 and 6								X		X	X		X			
7 and 8												X		X	X	X

[a] Regulatory alternatives with the "-25" suffix use exterior control options 1, 3, 5, and 7. Those with the "-25/40" suffix use exterior control options 2, 4, 6, and 8.

TABLE 1-2. MATRIX OF ENVIRONMENTAL AND ECONOMIC IMPACTS OF REGULATORY ALTERNATIVES

Regulatory Alternative	Air**	Water*	Solid Waste*	Energy***	Noise*	Economic*
I-25	0	0	0	0	0	0
II-25	+1	0	0	0	0	-2
III-25	+2	0	0	-1	0	-1
IV-25	+2	0	+1	-1	-2	-2
V-25	+2	0	0	0	0	+1
VI-25	+3	0	0	0	0	-2
VII-25	+3	0	0	-1	0	-1
VIII-25	+3	0	0	0	0	+4
IX-25	+3	0	+1	0	-2	-2
X-25	+3	0	0	0	0	+3
XI-25	+3	0	0	-1	0	+3
XII-25	+3	[illegible]	0	-1	0	0
XIII-25	+3	0	+1	0	-2	-2
XIV-25	+4	0	0	-1	0	-2
XV-25	+4	0	0	-1	0	-1
XVI-25	+4	0	+1	-1	-2	-2
I-25/40	+1	+1	+2	0	0	+3
II-25/40	+2	+1	+2	0	0	+2
III-25/40	+2	+1	+2	-1	0	+3
IV-25/40	+3	+1	+2	0	-2	-2
V-25/40	+3	+1	+2	0	0	+3
VI-25/40	+3	+1	+2	0	0	+2
VII-25/40	+3	+1	+2	-1	0	+3
VIII-25/40	+3	+1	+2	0	0	+4
IX-25/40	+3	+1	+2	0	-2	-1
X-25/40	+3	+1	+2	0	0	+4
XI-25/40	+4	+1	+2	-1	0	+4
XII-25/40	+3	+1	+2	-1	0	+3
XIII-25/40	+4	+1	+2	0	-2	+1
XIV-25/40	+4	+1	+2	-1	0	+2

(continued)

TABLE 1-2. (continued)

Regulatory Alternative	Air**	Water*	Solid Waste*	Energy***	Noise*	Economic*
XV-25/40	+4	+1	+2	-1	0	+2
XVI-25/40	+4	+1	+2	-1	-2	-2
Delayed Standard	0	0	0	0	0	0

Key:
- = Adverse impact
+ = Beneficial impact
* = Short term impact
** = Long term impact
*** = Irreversible impact
0 = No impact
1 = Negligible impact
2 = Small impact
3 = Moderate impact
4 = Large impact

Regulatory alternative VIII-25/40 would decrease the cost of coating plastic business machine parts by $83 million in 1990 and increase employment in this industry by 4.16 percent. Detailed analyses of the costs and economic impacts of the regulatory alternatives are presented in Chapters 8 and 9.

2. INTRODUCTION

2.1 BACKGROUND AND AUTHORITY FOR STANDARDS

Before standards of performance are proposed as a Federal regulation, air pollution control methods available to the affected industry and the associated costs of installing and maintaining the control equipment are examined in detail. Various levels of control based on different technologies and degrees of efficiency are expressed as regulatory alternatives. Each of these alternatives is studied by EPA as a prospective basis for a standard. The alternatives are investigated in terms of their impacts on the economics and well-being of the industry, the impacts on the national economy, and the impacts on the environment. This chapter summarizes the types of information obtained by EPA through these studies in the development of the proposed standards.

Standards of performance for new stationary sources are established under Section 111 of the Clean Air Act (42 U.S.C. 7411) as amended, hereafter referred to as the Act. Section 111 directs the Administrator to establish standards of performance for any category of new stationary source of air pollution which ". . . causes, or contributes significantly to air pollution which may reasonably be anticipated to endanger public health or welfare."

The Act requires that standards of performance for stationary sources reflect ". . . the degree of emission limitation and the percentage reduction achievable through application of the best technological system of continuous emission reduction which (taking into consideration the cost of achieving such emission reduction, any nonair quality health and environmental impact and energy requirements) the Administrator determines has been adequately demonstrated." The standards apply only to stationary sources, the construction or modification of which commences after the standards are proposed in the Federal Register.

The 1977 amendments to the Act altered or added numerous provisions that apply to the process of establishing standards of performance. Examples of the effects of the 1977 amendments are:

1. The EPA is required to review the standards of performance every 4 years and, if appropriate, revise them.

2. The EPA is authorized to promulgate a standard based on design, equipment, work practice, or operational procedures when a standard based on emission levels is not feasible.

3. The term "standards of performance" is redefined, and a new term "technological system of continuous emission reduction" is defined. The new definitions clarify that the control system must be continuous and may include a low- or non-polluting process or operation.

4. The time between the proposal and promulgation of a standard under Section 111 of the Act may be extended to 90 days.

Standards of performance, by themselves, do not guarantee protection of health or welfare because they are not designed to achieve any specific air quality levels. Rather, they are designed to reflect the degree of emission limitation achievable through application of the best adequately demonstrated technological system of continuous emission reduction, taking into consideration the cost of achieving such emission reduction, any nonair quality health and environmental impact and energy requirements.

Congress had several reasons for including these requirements. First, standards having a degree of uniformity are needed to avoid situations where some States may attract industries by relaxing standards relative to other States. Second, stringent standards may help achieve long-term cost savings by avoiding the need for more expensive retrofitting when pollution ceilings may be reduced in the future. Third, certain types of standards for coal-burning sources can adversely affect the coal market by driving up the price of low-sulfur coal or by effectively excluding certain coals from the reserve base due to their high untreated pollution potentials. Congress does not intend that new source performance standards contribute to these problems. Fourth, the standard-setting process should create incentives for improving technology.

Promulgation of standards of performance does not prevent State or local agencies from adopting more stringent emission limitations for the same sources. States are free under Section 116 of the Act to establish even more stringent emission limits than those established under Section 111 or than those necessary to attain or maintain the National Ambient Air Quality Standards (NAAQS) under Section 110. Thus, new sources may in some cases be subject to State limitations that are more stringent than standards of performance under Section 111, and prospective owners and operators of new sources should be aware of this possibility in planning for such facilities.

A similar situation may arise when a major emitting facility is to be constructed in a geographic area that falls under the prevention of significant deterioration of air quality provisions of Part C of the Act. These provisions require, among other things, that major emitting facilities to be constructed in such areas are to be subject to best available control technology. The term "best available control technology" (BACT), as defined in the Act, means

> . . . an emission limitation based on the maximum degree of reduction of each pollutant subject to regulation under this Act emitted from or which results from any major emitting facility, which the permitting authority, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such facility through application of production, processes and available methods, systems, and techniques, including fuel cleaning or treatment or innovative fuel combustion techniques for control of each such pollutant. In no event shall application of "best available control technology" result in emissions of any pollutants which will exceed the emissions allowed by any applicable standard established pursuant to Section 111 or 112 of this Act. (Section 169(3))

Although standards of performance are normally structured in terms of numerical emission limits where feasible, alternative approaches are sometimes necessary. In some cases, physical measurement of emissions from a new source may be impractical or exorbitantly expensive. Section 111(h) provides that the Administrator may promulgate a design or equipment standard in those cases where it is not feasible to prescribe or enforce a standard of performance. For example, emissions of hydrocarbons from storage vessels for petroleum liquids are greatest during tank filling. The nature of the emissions (i.e., high concentrations for short periods during filling and low concentrations for longer periods during storage) and the configuration of storage tanks make direct emission measurement impractical. Therefore, a more practical approach to standards of performance for storage vessels has been equipment specification.

In addition, under Section 111(j) the Administrator may, with the consent of the Governor of the State in which a source is to be located, grant a waiver of compliance to permit the source to use an innovative technological system or systems of continuous emission reduction. To grant the waiver, the Administrator must find that: (1) the proposed system has not been adequately demonstrated, (2) the proposed system will operate effectively and there is a substantial likelihood that the system will achieve greater emission reductions than the otherwise applicable standards require or at least an equivalent reduction at lower economic, energy, or nonair quality environmental cost, (3) the proposed system will not cause or contribute to an unreasonable risk to public health, welfare, or safety, and (4) the waiver, when combined with other similar waivers, will not exceed the number necessary to achieve conditions (2) and (3) above. A waiver may have conditions attached to ensure the source will not prevent attainment of any NAAQS. Any such condition will be treated as a performance standard. Finally, waivers have definite end dates and may be terminated earlier if the conditions are not met or if the system fails to perform as expected. In such a case, the source may be given up to 3 years to meet the standards and a mandatory compliance schedule will be imposed.

2.2 SELECTION OF CATEGORIES OF STATIONARY SOURCES

Section 111 of the Act directs the Administrator to list categories of stationary sources. The Administrator ". . . shall include a category of sources in such list if in his judgment it causes, or contributes significantly to air pollution which may reasonably be anticipated to endanger public health or welfare." Proposal and promulgation of standards of performance are to follow.

Since passage of the Clean Air Amendments of 1970, considerable attention has been given to the development of an approach for assigning priorities to various source categories. The approach specifies areas of interest by considering the broad strategy of the Agency for implementing the Clean Air Act. Often, these areas concern pollutants that are emitted by stationary sources rather than the stationary sources themselves. Source categories that emit these pollutants were evaluated and ranked considering such factors as: (1) the level of emission control (if any) already required by State regulations, (2) estimated levels of control that might be required from standards of performance for the source category, (3) projections of growth and replacement of existing facilities for the source category, and (4) the estimated incremental amount of air pollution that could be prevented in a preselected future year by standards of performance for the source category. Sources for which new source performance standards were promulgated or which were under development before or during 1977, were selected using these criteria.

The Act amendments of August 1977 establish specific criteria to be used in determining priorities for all source categories not yet listed by EPA. These are: (1) the quantity of air pollutant emissions which each such category will emit, or will be designed to emit, (2) the extent to which each such pollutant may reasonably be anticipated to endanger public health or welfare, and (3) the mobility and competitive nature of each such category of sources and the consequent need for nationally applicable new source performance standards. The Administrator is to promulgate standards for these categories according to the schedule referred to earlier.

In some cases, it may not be immediately feasible to develop standards for a source category with a high priority. This might happen if a program of research is needed to develop control techniques or if techniques for sampling and measuring emissions require refinement. In the development of standards, differences in the time required to complete the necessary investigation for different source categories must also be considered. For example, substantially more time may be necessary if numerous pollutants must be investigated from a single source category.

Further, the schedule for completion of a standard may change late in the development process. For example, inability to obtain emission data from well-controlled sources in time to pursue the development process in a systematic fashion may force a change in scheduling. Nevertheless, priority ranking is, and will continue to be, used to establish the order in which projects are initiated and resources are assigned.

After the source category has been chosen, the types of facilities within the source category to which the standard will apply must be determined. A source category may have several facilities that cause air pollution, and emissions from these facilities may vary according to magnitude and control cost. Economic studies of the source category and of applicable control technology may show that air pollution control is better served by applying standards to the more severe pollution sources. For this reason, and because there is no adequately demonstrated system for controlling emissions from certain facilities, standards often do not apply to all facilities at a source. For the same reasons, the standards may not apply to all air pollutants emitted. Thus, although a source category may be selected to be covered by standards of performance, not all pollutants or facilities within that source category may be covered by the standards.

2.3 PROCEDURE FOR DEVELOPMENT OF STANDARDS OF PERFORMANCE

Standards of performance must: (1) realistically reflect best demonstrated control practice, (2) adequately consider the cost, the nonair quality health and environmental impacts, and the energy requirements of such control, (3) be applicable to existing sources that are modified or reconstructed as well as to new installations, and (4) meet these conditions for all variations of operating conditions being considered anywhere in the country.

The objective of a program for development of standards is to identify the best technological system of continuous emission reduction that has been adequately demonstrated. The standard-setting process involves three principal phases of activity: (1) information gathering, (2) analysis of the information, and (3) development of the standards of performance.

During the information gathering phase, industries are questioned through telephone surveys, letters of inquiry, and plant visits by EPA representatives. Information is also gathered from other sources, including a literature search. Based on the information acquired about the industry, EPA selects certain plants at which emission tests are conducted to provide reliable data that characterize the pollutant emissions from well-controlled existing facilities.

In the second phase of a project, the information about the industry and the pollutants emitted is used in analytical studies. Hypothetical "model plants" are defined to provide a common basis for analysis. The model plant definitions, national pollutant emission data, and existing State regulations governing emissions from the source category are then used in establishing "regulatory alternatives." These regulatory alternatives are essentially different levels of emission control.

The EPA conducts studies to determine the impact of each regulatory alternative on the economics of the industry and on the national economy, on the environment, and on energy consumption. From several alternatives, EPA selects the single most plausible regulatory alternative as the basis for standards of performance for the source category under study.

In the third phase of a project, the selected regulatory alternative is translated into performance standards, which, in turn, are written in the form of a Federal regulation. The Federal regulation, when applied to newly constructed plants and to modified or reconstructed facilities, will limit emissions to the levels indicated in the selected regulatory alternative.

As early as is practical in each standard-setting project, EPA representatives discuss the possibilities of a standard and the form it might take with members of the National Air Pollution Control Techniques Advisory Committee. Industry representatives and other interested parties also participate in these meetings.

The information acquired in the project is summarized in the background information document (BID). The BID, the proposed standards, and a preamble explaining the standards are widely circulated to the industry being considered for control, environmental groups, other government agencies, and offices within EPA. Through this extensive review process, the points of view of expert reviewers are taken into consideration as changes are made to the documentation.

A "proposal package" is assembled and sent through the offices of EPA assistant administrators for concurrence before the proposed standards are officially endorsed by the EPA Administrator. After being approved by the EPA Administrator, the preamble and the proposed regulation are published in the Federal Register.

The public is invited to participate in the standard-setting process as part of the Federal Register announcement of the proposed regulation. The EPA invites written comments on the proposal and also holds a public hearing to discuss the proposed standards with interested parties. All public comments are summarized and incorporated into a second volume of the BID. All information reviewed and generated in studies in support of the standards of performance is available to the public in a "docket" on file in Washington, D.C. Comments from the public are evaluated, and the standards of performance may be altered in response to the comments.

The significant comments and the EPA's position on the issues raised are included in the preamble of a promulgation package, which also contains the draft of the final regulation. The regulation is then subjected to another round of review and refinement until it is approved by the EPA Administrator. After the Administrator signs the regulation, it is published as a "final rule" in the Federal Register.

2.4 CONSIDERATION OF COSTS

Section 317 of the Act requires an economic impact assessment with respect to any standard of performance established under Section 111 of the Act. The assessment is required to contain an analysis of: (1) the costs of compliance with the regulation, including the extent to which the cost of compliance varies depending on the effective date of the regulation and the development of less expensive or more efficient methods of compliance, (2) the potential inflationary and recessionary effects of the regulation, (3) the effects the regulation might have on small business with respect to competition, (4) the effects of the regulation on consumer costs, and (5) the effects of the regulation on energy use. Section 317 requires that the economic impact assessment be as extensive as practicable.

The economic impact of proposed standards upon an industry is usually addressed both in absolute terms and by comparison with the control costs that would be incurred as a result of compliance with typical, existing State control regulations. An incremental approach is taken because both new and existing plants would be required to comply with State regulations in the absence of Federal standards of performance. This approach requires a detailed analysis of the economic impact of the cost differential that would exist between proposed standards of performance and typical State standards.

Air pollutant emissions may cause water pollution problems, and captured potential air pollutants may pose a solid waste disposal problem. The total environmental impact of an emission source must, therefore, be analyzed and the costs determined whenever possible.

A thorough study of the profitability and price-setting mechanisms of the industry is essential to the analysis so that an accurate estimate of potential adverse economic impacts can be made for proposed standards. It is also essential to know the capital requirements for pollution control systems already placed on plants so that the additional capital requirements necessitated by these Federal standards can be placed in proper perspective. Finally, it is necessary to assess the availability of capital to provide the additional control equipment needed to meet the standards of performance.

2.5 CONSIDERATION OF ENVIRONMENTAL IMPACTS

Section 102(2)(C) of the National Environmental Policy Act (NEPA) of 1969 requires Federal agencies to prepare detailed environmental impact statements on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment. The objective of NEPA is to build into the decision-making process of Federal agencies a careful consideration of all environmental aspects of proposed actions.

In a number of legal challenges to standards of performance for various industries, the United States Court of Appeals for the District of Columbia Circuit has held that environmental impact statements need not be prepared by the Agency for proposed actions under Section 111 of the Clean Air Act. Essentially, the Court of Appeals has determined that the best system of emission reduction requires the Administrator to take into account counterproductive environmental effects of proposed standards, as well as economic costs to the industry. On this basis, therefore, the Courts established a narrow exemption from NEPA for EPA determinations under Section 111.

In addition to these judicial determinations, the Energy Supply and Environmental Coordination Act (ESECA) of 1974 (PL-93-319) specifically exempted proposed actions under the Clean Air Act from NEPA requirements. According to Section 7(c)(1), "No action taken under the Clean Air Act shall be deemed a major Federal action significantly affecting the quality of the human environment within the meaning of the National Environmental Policy Act of 1969." (15 U.S.C. 793(c)(1))

Nevertheless, the Agency has concluded that the preparation of environmental impact statements could have beneficial effects on certain regulatory actions. Consequently, although not legally required to do so by Section 102(2)(C) of NEPA, EPA has adopted a policy requiring that environmental impact statements be prepared for various regulatory actions, including standards of performance developed under Section 111 of the Act. This voluntary preparation of environmental impact statements, however, in no way legally subjects the Agency to NEPA requirements.

To implement this policy, a separate section is included in this document that is devoted solely to an analysis of the potential environmental impacts associated with the proposed standards. Both adverse and beneficial impacts in such areas as air and water pollution, increased solid waste disposal, and increased energy consumption are discussed.

2.6 IMPACT ON EXISTING SOURCES

Section 111 of the Act defines a new source as ". . . any stationary source, the construction or modification of which is commenced . . ." after the proposed standards are published. An existing source is redefined as a new source if "modified" or "reconstructed" as defined in amendments to the General Provisions (40 CFR Part 60, Subpart A), which were promulgated in the Federal Register on December 16, 1975 (40 FR 58416).

Promulgation of standards of performance requires States to establish standards of performance for existing sources in the same industry under Section 111(d) of the Act if the standards for new sources limit emissions of a designated pollutant (i.e., a pollutant for which air quality criteria have not been issued under Section 108 or which has not been listed as a hazardous pollutant under Section 112). If a State does not act, EPA must establish such standards. General procedures for control of existing sources under Section 111(d) were promulgated on November 17, 1975, as Subpart B of 40 CFR Part 60 (40 FR 53340).

2.7 REVISION OF EXISTING STANDARDS OF PERFORMANCE

Congress was aware that the level of air pollution control achievable by any industry may improve with technological advances. Accordingly, Section 111 of the Act provides that the Administrator ". . . shall, at least every four years, review and, if appropriate, revise . . ." the standards. Revisions are made to ensure that the standards continue to reflect the best systems of emission reduction that become available in the future. Such revisions will not be retroactive but will apply to stationary sources constructed or modified after the proposal of the revised standards.

3. THE SURFACE COATING OF PLASTIC PARTS FOR BUSINESS MACHINES: PROCESSES AND POLLUTANT EMISSIONS

3.1 GENERAL

There are several industries that surface coat plastic parts for business machines: the business machine manufacturing industry (SIC 3573, 3574, and 3579); the plastic parts molding industry (SIC 3079); and the coating, engraving, and allied services industries (SIC 3471 and 3479).[1] Although some coating is done during repair and reconditioning of such machines, this is done in dispersed locations and at low volumes and has not been studied in the development of this document. Resin suppliers (SIC 2821), industrial coatings suppliers (SIC 2851), and coating equipment vendors (SIC 3564) supply the materials and equipment used to surface-coat plastic parts.[1] They interact with the molders and coaters of plastic parts and contribute significantly to research and development of new coating materials and processes.

Figure 3-1 illustrates the relationships among the industrial sectors involved in production of surface-coated plastic parts for business machines. One source estimates that over 3,000 facilities nationwide perform coating of plastic parts for business machines.[2] Plastic parts may be molded and coated in-house by business machine manufacturers; however, the molding and the coating of parts are frequently contracted out to other companies that specialize in these processes. The molding and coating steps may be performed by separate companies, or both steps may be performed at a single plant. Regardless of who actually performs the coating step, the finish quality (i.e., color, gloss, adhesion, chemical resistance, abrasion resistance, etc.) is specified by the business machine manufacturer. Business machine manufacturers usually specify one or more coatings that are acceptable for contract coaters to

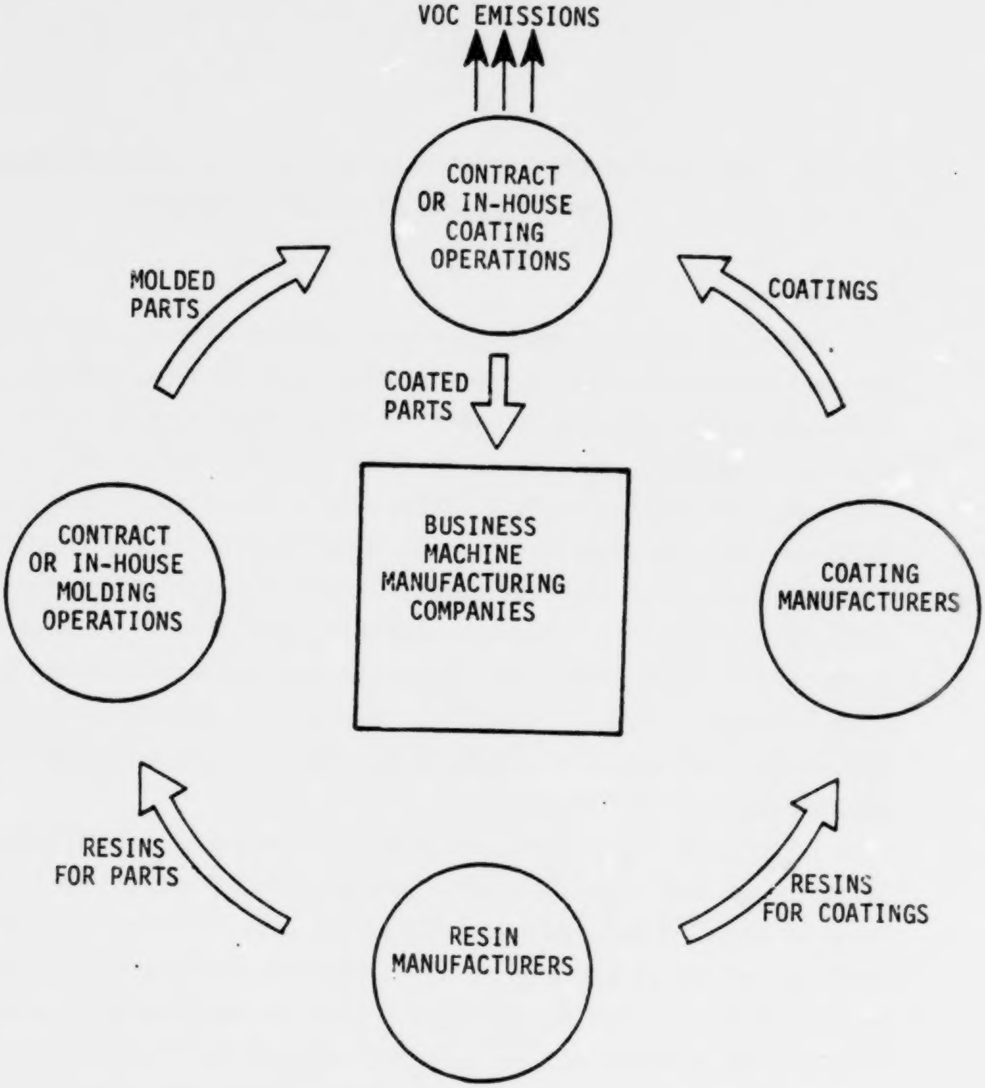
VOC EMISSIONS
CONTRACT OR IN-HOUSE COATING OPERATIONS
MOLDED PARTS
COATINGS
COATED PARTS
CONTRACT OR IN-HOUSE MOLDING OPERATIONS
BUSINESS MACHINE MANUFACTURING COMPANIES
COATING MANUFACTURERS
RESINS FOR PARTS
RESINS FOR COATINGS
RESIN MANUFACTURERS

Figure 3-1. Relationship among industrial sectors involved in the surface coating of plastic parts for business machines.

use. Both organic-solvent-based coatings and waterborne coatings may be specified for application to plastic business machine parts. Although waterborne coatings use water as their primary solvent, they also contain some organic solvents. Volatile organic compounds (VOC) are emitted to the atmosphere during the coating and curing processes when organic solvents and other volatile organic components evaporate from the coatings.

Resins that are commonly used to produce plastic business machine parts include acrylonitrile-butadiene-styrene (ABS), polycarbonate (PC), polyphenylene oxide (PPO), polystyrene (PS), and polyurethane (PU).[3-13] Various other plastics such as polypropylene (PP) and fiberglass reinforced sheet molding compound (SMC) are used less frequently.[6-14]

3.2 FACTORS INFLUENCING SURFACE COATING OF PLASTIC PARTS

Plastic parts for business machines are coated for three major reasons: (1) to improve their appearance; (2) to protect the plastic part from physical and chemical stress; and (3) to attenuate electromagnetic interference/radio frequency interference (EMI/RFI) signals that would otherwise pass through plastic housings.

3.2.1 Factors Influencing Exterior Coating

3.2.1.1 Molding Techniques. The need to apply decorative coatings to plastic parts to improve their appearance and to meet manufacturer and buyer preferences is determined to a large extent by the molding techniques employed. Structural foam injection molding and straight injection molding are the two predominant forming techniques, although some compression molding and reaction injection molding (RIM) of plastic parts is performed.[14] Each accounts for slightly less than 50 percent of plastic business machine housing production.[14] Structural foam injection molding produces parts with surface flaws that require substantial surface coating, whereas, straight injection molding can produce parts with molded-in color and texture that require little or no decorative surface coating.[4,5,15-18] It follows that finishing costs, when considered alone, favor the use of straight injection molding. However, tooling for structural foam molds costs from one-third to two-thirds less than for injection molds.[15,19] Therefore, molding costs favor the use of structural foam injection molding, especially for large, complex-shaped parts.

3.2.1.2 Other Factors Influencing Exterior Coating.

Plastic parts are often coated to match the color and texture of metal parts or other plastic parts. Color matching is often difficult to achieve with molded-in color; however, only a small percentage of straight-injection-molded parts receive decorative exterior coatings. Color reproducibility and color stability of plastic parts are generally more easily controlled by coating the parts than by using molded-in color.[5,18,20-21]

The surface characteristics of the molded part and, therefore, the amount of surface finishing required for a part are influenced by the design of the part, the design of the mold, and molding parameters such as injection rate, molding temperature, and injection pressure.[22] Many surface flaws that require sanding, filling, and application of coatings that emit VOC can be minimized by close interaction among the business machine part designers, molding and coating line personnel, and the suppliers of equipment and materials.[22] Reducing the number and the severity of surface flaws can reduce the total film thickness of coating necessary to hide them.

In addition to improving the appearance of plastic parts, coatings can protect the parts from various environmental stresses. The specific end use of the parts determines which of the following physical characteristics is most critical: color, gloss, adhesion, pencil hardness, impact resistance, flexibility, abrasion resistance, ultraviolet (UV) light stability, salt resistance, and solvent resistance. For instance, an office copying machine should have a durable finish that is resistant to abrasion because the machine is used frequently. On the other hand, durability may not be as critical for the finish on a desktop computer housing as color and gloss may be.[23] Some business machine manufacturers perform laboratory tests that measure these characteristics for different coatings. The outcome of the tests influences the particular coating(s) they specify for application to their products.[24]

3.2.2 Physical and Chemical Limitations of Plastics

The properties of the plastics used to make business machine parts determine the types of coatings that can be used. Some plastics are damaged by organic solvents present in organic-solvent-based and waterborne coatings. Another important property of plastic parts is their tendency to deform at temperatures normally used to cure coatings on metal parts. Coatings on plastic parts are typically cured at temperatures of 60°C (140°F) or less, whereas many coatings used on metal parts are cured at temperatures exceeding 93°C (200°F).[7-13,25,26] For this reason, many coatings used on metal cannot be used on plastic.

3.2.3 Factors Influencing EMI/RFI Shielding

Unlike metal business machine housings, which are conductive, plastic housings allow the passage of EMI/RFI signals that are emitted from the enclosed electronic components. The EMI/RFI signals emitted from business machines can interfere with the performance of other electronic devices such as radios and televisions. Conversely, EMI/RFI signals from outside sources can interfere with performance of the electronic components within an unshielded plastic business machine housing. The increased use of plastics for business machine housings and the increase in circuit density afforded by advances in circuit technology have resulted in a corresponding increase in EMI/RFI interruption of the airwaves.[27] To combat EMI/RFI propagation, the Federal Communications Commission (FCC) has regulated EMI/RFI emissions from computing devices.[28] The limitations for the electric field strength from computing devices, which are outlined in Table 3-1, have caused a rapid increase in the use of EMI/RFI shielding materials.[29]

The two major performance specifications for EMI/RFI shielding materials are conductivity and adhesion. Conductivity is required for both EMI/RFI shielding and electrostatic discharge (ESD) protection. The EMI/RFI signals are best shielded with grounded, high conductivity coatings. These coatings usually have a surface resistance of less than 1 ohm per square. However, ESD protection is best achieved with grounded, low conductivity coatings with surface resistance of 2 to 20 ohms per square. Although a high conductivity surface may prevent a spark from reaching internal electronic components in one area of a housing, the spark may arc to the internal components in another area as it travels directly to the grounding connection. A low conductivity surface spreads the energy over a larger area as it travels to ground, preventing a build-up of localized charge.[30]

TABLE 3-1. EMI/RFI RADIATION LIMITS ESTABLISHED BY THE FCC[28]

Frequency, MHz[c]	Class A Computing Devices[a] μV/m[d], measured at 30 m[e]	Class B Computing Devices[b] μV/m, measured at 30 m
30-88	30	100
88-216	50	150
216-1000	70	200

[a] Class A devices are defined in Section 15.4(o) of the FCC Rules [47 CFR 15.4(o)] as computing devices marketed for use in a commercial, industrial, or business environment.

[b] Class B devices are defined in Section 15.4(p) of the FCC Rules [47 CFR 15.4(p)] as computing devices marketed for use in a residential environment notwithstanding use in a commercial, industrial, or business environment.

[c] MHz = megahertz.

[d] μV/m = microvolts/meter.

[e] m = meter.

Adhesion is measured by a procedure developed by Underwriters Laboratories, Incorporated (UL). Test panels of coated plastic are subjected to high temperature, high temperature and humidity, and thermal cycling, and then evaluated according to how well the coating adheres to the plastic. Coatings that pass these tests are listed with UL and are considered to be safe from the risk of electrical shock, fire, or personal injury.[31-33]

3.3 PROCESSES OR FACILITIES AND THEIR EMISSIONS

Surface coating processes for plastic parts used in business machines fall into two categories: coating processes that provide EMI/RFI shielding and coating processes that provide decorative/protective finishes. Figure 3-2 illustrates the two major divisions of coating processes and the general steps involved in each process. Not all plastic parts undergo both coating processes. For example, a plastic business machine housing with satisfactory molded-in color and texture may require an EMI/RFI shielding coating, but not a decorative/protective coating. Similarly, not all plastic parts that receive decorative/ protective coatings require EMI/RFI shielding. If both processes are required, EMI/RFI shielding is normally done first.

3.3.1 Coating Application Methods

Coatings are spray applied in this industry. Other coating techniques such as flow coating and dip coating may be used infrequently for specialized, low volume applications. In all spray coating operations, some coating solids are wasted because they either miss or bounce off the part. Coating solids that do not adhere to the part are called overspray. Transfer efficiency is the ratio of the amount of coating solids deposited on a surface to the total amount of coating solids sprayed.

3.3.1.1 Spray Systems. The three basic spray methods used in this industry are air atomized spray, air-assisted airless spray, and electrostatic air spray. Air atomized spray is the most widely used coating technique for plastic business machine parts.[4,7-13] Air-assisted airless spray is growing in popularity but is still not frequently used.[4,7-13] Electrostatic air spray is only rarely used

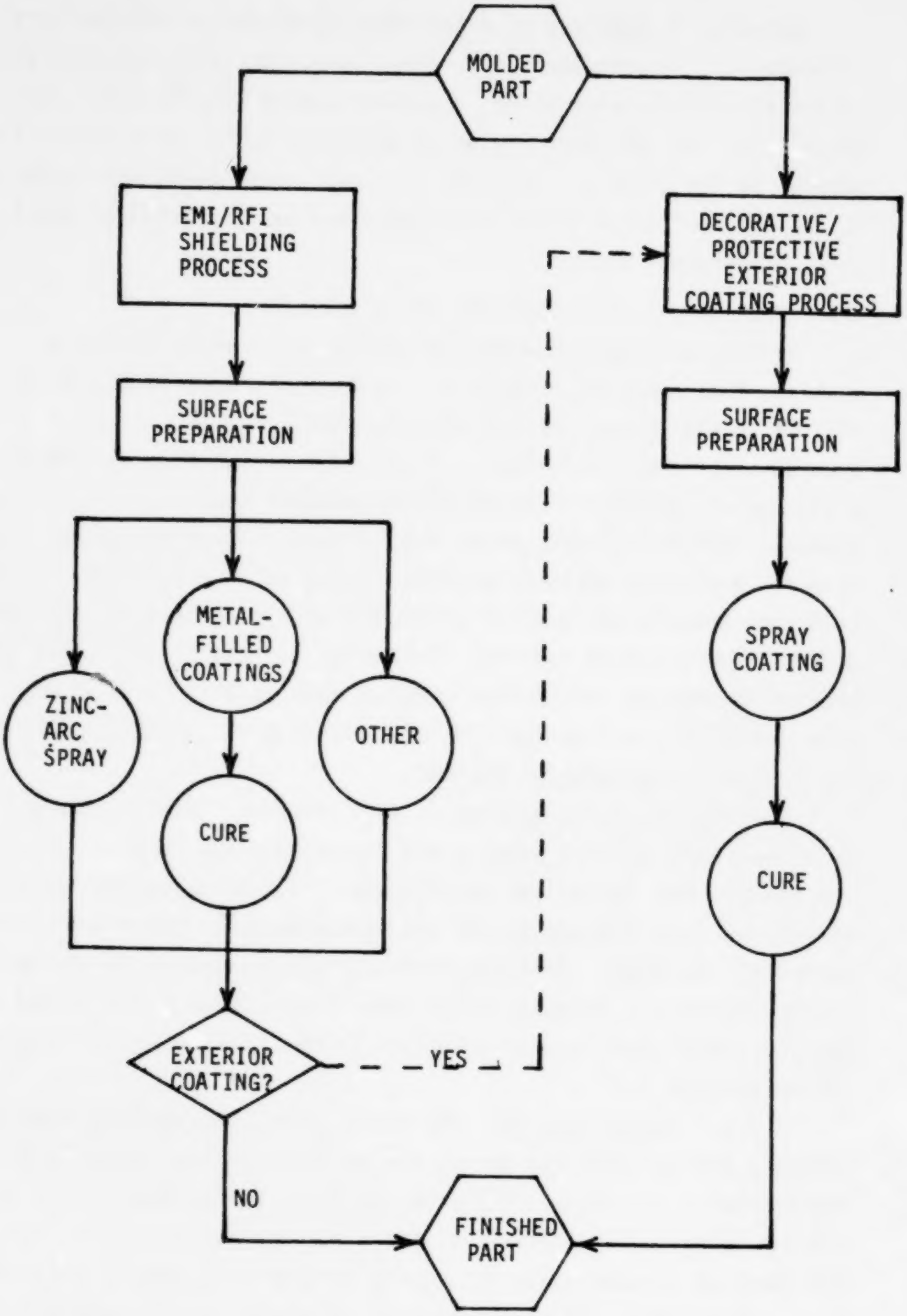
MOLDED PART
EMI/RFI SHIELDING PROCESS
DECORATIVE/ PROTECTIVE EXTERIOR COATING PROCESS
SURFACE PREPARATION
SURFACE PREPARATION
ZINC-ARC SPRAY
METAL-FILLED COATINGS
OTHER
CURE
SPRAY COATING
CURE
EXTERIOR COATING?
YES
NO
FINISHED PART

Figure 3-2. Coating processes for plastic parts used in business machines.

because plastic parts are not conductive; however, it has been demonstrated for parts which have first been treated with a conductive sensitizer or plated with a thin film of metal.[34-37]

Air atomized spray coating uses compressed air, which may be heated and filtered, to atomize the coating and to direct the spray. Air atomized spray equipment is compatible with all coatings that are commonly used on plastic parts for business machines. Although transfer efficiencies vary depending upon the shape of the target, the type of coating used, and other factors, they tend to be lower with this method than with other application methods.[4] Transfer efficiencies for air atomized spray have been estimated to be over 50 percent in some cases and as low as 15 percent in others.[4,7-13,19,38-48] Based on the available information, the average transfer efficiency for air atomized spray has been estimated to be about 25 percent for exterior coatings and about 50 percent for EMI/RFI shielding coatings. The higher transfer efficiency for EMI/RFI shielding is the result of two major factors. First, the pressure at the spray gun is less for EMI/RFI shielding, which reduces the degree of coating bounceback. Bounceback occurs when the coating from the gun encounters a barrier of compressed air and entrained coating that is moving away from the surface of the part. Second, EMI/RFI shielding coatings are usually applied to the interior surface of a cabinet or housing, so coating that may bounce off one wall will likely encounter another wall.

Air-assisted airless spray is a variation of airless spray, a spray technique used in other industries. In airless spray coating, the coating is atomized without air by forcing the liquid coating through specially designed nozzles, usually at pressures of 7 to 21 Megapascals (MPa) (1,000 to 3,000 psi).[49] Air-assisted airless spray atomizes the coating by the same mechanism as airless spray, but at lower fluid pressures (<7 mPa).[50] A small amount of air is used to further atomize the coating and to help shape the spray pattern, reducing the amount of overspray below that achieved with airless atomization alone.[50] The transfer efficiency of air-assisted airless spray guns is discussed in Chapter 4.

In electrostatic air spray, usually the coating is charged and the parts being coated are grounded to create an electric potential between the coating and the parts. The atomized coating is attracted to the part by electrostatic force. Because plastic is an insulator, it is necessary to provide a conductive surface that can bleed off the electrical charge to maintain the ground potential of the part as the charged coating particles accumulate on the surface.[38] Conductivity of the plastic surface can be achieved by deposition of a thin metal film onto the surface of the plastic part or by application of a conductive sensitizer onto the part. These are the only two methods that have been used successfully in production for electrostatic air spray coating of plastic parts used in business machines.[34-36] Other methods that have been used to coat plastic parts electrostatically include the use of conductive (waterborne) coatings and the placement of a grounded metal image behind the part being coated.[37,38,51,52] No one is known to use these methods for production coating of plastic business machine parts. Transfer efficiencies for electrostatic air spray coating of plastic parts are discussed in Chapter 4.

3.3.2 EMI/RFI Shielding Processes

EMI/RFI shielding is done in a variety of ways. The relative use of each is as follows: about 45 percent is done by zinc-arc spraying, a process which does not emit VOC; approximately 45 percent is accomplished using organic-solvent-based and waterborne metal-filled coatings; and the remaining EMI/RFI shielding is achieved by a variety of techniques that include electroless plating, the use of conductive plastics, the use of metal inserts, vacuum metallizing, and sputtering.[29,40,53] These processes are described in the following sections.

3.3.2.1 Zinc-Arc Spray. Zinc-arc spraying is a two-step process in which the plastic surface (usually the interior of a housing) is first roughened by sanding or grit-blasting, and then spray-coated with molten zinc. Both the surface preparation and the zinc-arc spraying steps are currently performed manually; however, robot-operated systems have recently become available.[54,55]

Zinc-arc spraying requires a spray booth, a special spray gun, pressurized air, and zinc wire. The process generates noise and smoke; therefore, protective equipment for the operators is necessary. Intense light is also generated.[54-56]

The zinc-arc spray gun operates by mechanically feeding two zinc wires into the tip of the spray gun, where they are melted by an electric arc. A high-pressure air nozzle blows the molten zinc particles onto the surface of the plastic part. A zinc coating thickness ranging from 1 to 4 mils (1 mil = .001 inch) is common, depending upon shielding requirements.[56]

3.3.2.2 Spray Application of Conductive Coatings. Both organic-solvent-based and waterborne coatings are being used for EMI/RFI shielding. Organic-solvent-based conductive coatings contain particles of nickel, silver, copper, or graphite, in either an acrylic or urethane resin. Nickel-filled acrylic coatings are the most frequently used because of their shielding ability and cost.[4,57,58] Nickel-filled urethane coatings are more expensive than nickel-filled acrylic coatings, but are reported to give a more durable finish.[4,57,58] Nickel-filled acrylics and urethanes that contain from 15 to 25 percent, by volume, solids at the gun (i.e., at the point of application or as applied) are being used to coat plastic business machine parts.[7-13]

Waterborne nickel-filled acrylics containing between 25 and 34 percent, by volume, solids at the gun (approximately 50 to 60 percent, by volume, solids, minus water) are being used less frequently than organic-solvent-based conductive coatings. These waterborne conductive coatings contain approximately 0.23 to 0.47 kg VOC/ℓ of coating (1.9 to 3.9 lb VOC/gal of coating), minus water.[59-61] Some coaters feel that waterborne conductive coatings do not adhere as well to plastic as do organic-solvent-based conductive coatings, but there are at least two waterbornes that are UL-approved for adhesion.[62]

Conductive coatings can be applied with most conventional spray equipment. They are usually applied manually with air spray guns, although air-assisted airless spray guns are sometimes used. Electrostatic spray methods cannot be used because of the high conductivity of the EMI/RFI shielding coatings.[37] Because of the density of metal particles, paint pots with agitators are used to prevent the particles from settling prior to application.[20,58,63]

The coating process usually involves three steps: surface preparation, coating application, and curing. Although the first step can be eliminated if the parts are kept free of mold-release agents and dirt, part surfaces are usually cleaned by wiping with organic solvents or detergent solutions and roughened by light sanding.[58] The coatings are usually applied to the interior surface of plastic housings at a dry film thickness of 1 to 3 mils.[7-13] Most conductive coatings can be cured at room temperature, but some must be baked in an oven.

3.3.2.3 Other EMI/RFI Shielding Methods. Other EMI/RFI shielding processes include electroless plating, vacuum metallizing, sputtering, the use of conductive plastics, and the use of metal inserts. None of these techniques represent a significant portion of the EMI/RFI shielding market at the present time.[29]

Electroless plating is a dip process in which a film of metal is deposited from aqueous solution onto all exposed surfaces of the part. In the case of plastic business machine housings, both sides of the housing are coated. No VOC emissions are associated with the plating process itself. However, coatings that emit VOC's may be applied prior to the plating step so that only selected areas of the parts are plated.[64] Water treatment may be necessary when the electroless plating process is used.

Vacuum metallizing and sputtering are similar techniques in which a thin film of metal (usually aluminum) is deposited from the vapor phase onto the plastic part. Although no VOC emissions occur during the actual metallizing process, VOC-emitting prime coats that ensure good adhesion and top coats that protect the metal film are often applied.

Conductive plastics are thermoplastic resins that contain conductive flakes or fibers composed of materials such as aluminum, steel, metallized glass, or carbon. Resin types that are available with conductive fillers include ABS, ABS/PC blends, PPO, nylon 6/6, polyvinyl chloride, and polybutyl terephthalate.[27,65,66] The conductivity and, therefore, the EMI/RFI shielding effectiveness of these materials relies on contact or close proximity between the conductive particles within the resin matrix.[65,66] Conductive plastic parts are usually formed by straight injection molding.[66] Structural foam injection molding can reduce the EMI/RFI shielding effectiveness of these materials because air pockets within the structural foam separate the conductive particles.[66]

3.3.3 Coating of Parts for Decorative/Protective Purposes

3.3.3.1 The Coating Process. The general process for spray coating of parts was shown in Figure 3-2. The three basic steps in the process are surface preparation, spray coating, and curing. Each step may be repeated several times for a given part.

The surface preparation step may involve merely wiping off the surface or may involve sanding and puttying to smooth the surface. Parts are spray-coated in partially enclosed booths. An induced air flow is maintained through the booths to remove overspray and to keep solvent concentrations at a safe level. Dry filters or water curtains are used to remove overspray particles from the booth exhaust. Coatings may be partially or completely cured at room temperature, but ovens are usually employed to speed up the curing process.

Spray coating systems commonly used in this industry fall into three categories: the three-coat system, the two-coat system, and the single-coat system. The three-coat system is the most commonly used coating system for structural foam parts.[6] The three-coat system consists of a prime coat, a color or base coat, and a texture coat. Typical dry film thickness ranges from 1 to 3 mils for the prime coat and is about 1 to 2 mils for the color coat.[3,5,7-13] The texture coat is a spatter coat consisting of discrete, raised spots of paint; therefore, a true, continuous film thickness cannot be measured. An effective film thickness of 1 to 5 mils, however, is frequently estimated for the texture coat.[3,5,7-13] The same coating is generally used for the color coat and texture coat, but the texture coat is applied at a lower atomization pressure and a higher viscosity. The two-coat system employs a color or base coat and a texture coat. Typical dry film thicknesses for the color coat and texture coat are 2 mils and 2 to 5 mils, respectively.[7-13]

The single-coat system is not frequently used. This process employs a low solids color coat to protect the plastic substrate or improve color matching between parts with molded-in color and texture.[18] Less coating solids are applied with the single-coat system than with the other systems. The dry film thickness applied for the single-coat system depends on the function of the coating. If protective properties are desired, the dry film thickness must be at least 1 mil. For purposes of color matching between parts with molded-in color and texture, a dry film thickness of 0.5 mil or less is needed to avoid masking the molded-in texture. The process of applying 0.5 mil or less of coating solids for color matching is commonly known as "fog coating," "mist coating," or "uniforming."

A typical conveyorized coating line using the three-coat system is depicted in Figure 3-3. The conveyorized line consists of three separate spray booths, each followed by a flash-off area. The final flash-off area is followed by a curing oven.

3.3.3.2 Organic-Solvent-Based Coatings. The most frequently used exterior coatings for plastic parts used in business machines are organic-solvent-based two-component catalyzed urethanes. These coatings may represent as much as 90 percent of the exterior decorative/protective coatings currently being used on plastic parts for business machines.[4,6,18] The isocyanate catalysts in these coatings allow them to cure at low temperatures.

The most frequently used two-component urethanes contain roughly 30 to 35 percent, by volume, solids at the gun.[4,6,18] Conventional air atomized spray guns and paint pots can be used with these coatings. Air-assisted airless and electrostatic air spray equipment can also be used to apply these coatings. The pot life of the catalyzed urethanes in this solids range is sufficiently long (approximately 8 hours) that the coating and the catalyst can be pre-mixed.

Although they are not as common, urethanes containing between 40 and 54 percent, by volume, solids at the gun are being used routinely by some coaters.[4,6,18,67,68] Air atomized, air-assisted airless, and electrostatic air spray equipment may be used with these coatings. The pot life of these urethanes is approximately 1 to 4 hours once the

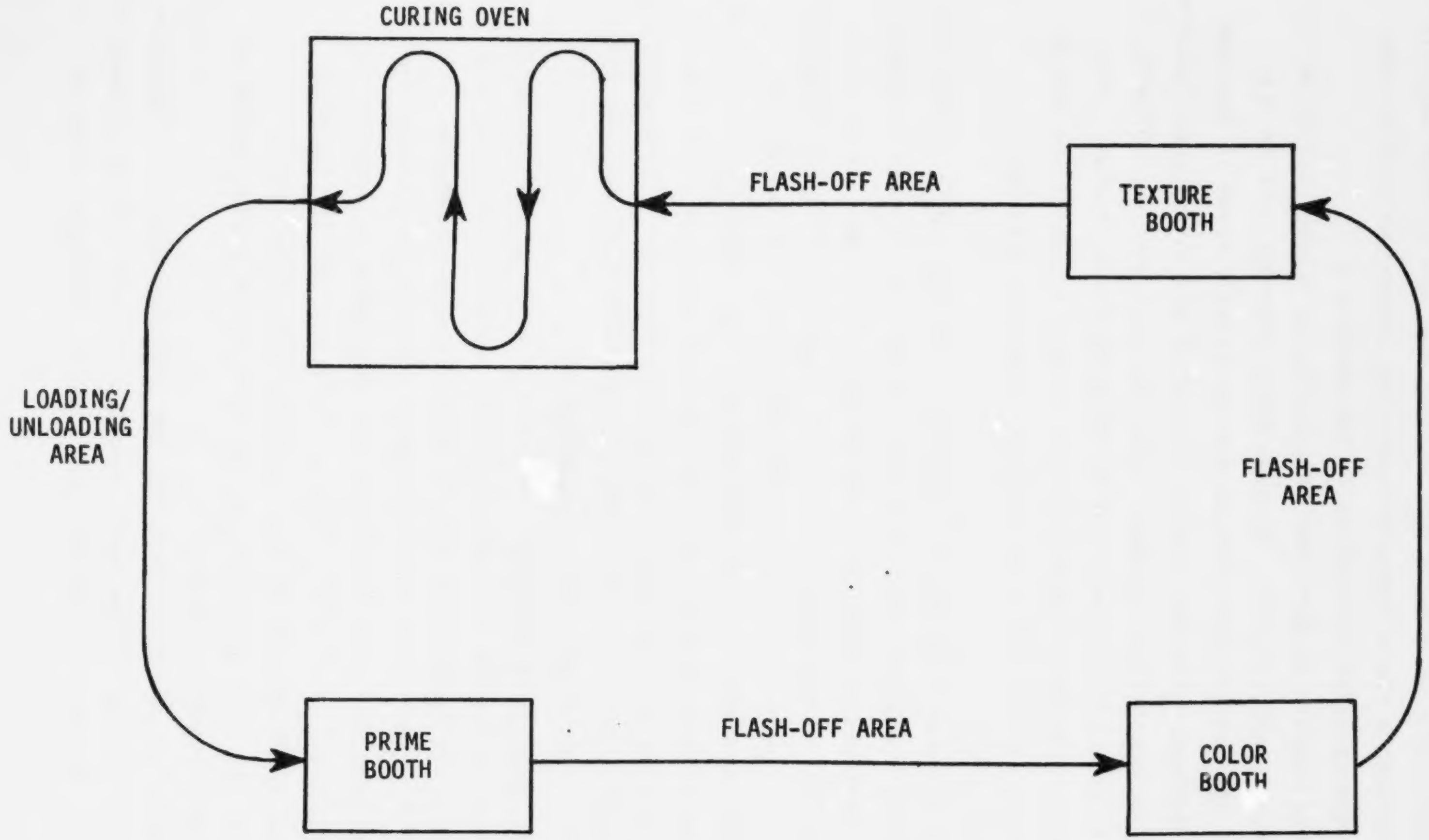
CURING OVEN
FLASH-OFF AREA
TEXTURE BOOTH
LOADING/ UNLOADING AREA
FLASH-OFF AREA
PRIME BOOTH
FLASH-OFF AREA
COLOR BOOTH

Figure 3-3. Typical conveyorized coating line for three-coat system.

coating and catalyst are mixed.[4,18] The effective pot life can be extended indefinitely by drawing the catalyst and coating from separate reservoirs through a plural-component metering system, which mixes the coating and the catalyst at or prior to the spray gun.

Urethanes containing more than 60 percent, by volume, solids at the gun are currently experimental. Because these coatings cure in less than 1 hour, the coating and catalyst are not usually mixed in the same reservoir. Instead, they may require the use of plural-component metering equipment with high-pressure pumps. These coatings were used briefly in production to coat plastic parts for business machines; however, they were reformulated at about 53 percent, by volume, solids at the gun to extend their pot life without using plural component metering equipment.[2,63,68-72]

Organic-solvent-based acrylic coatings are being used to a limited extent on plastic business machine parts. These coatings are available with solids contents of about 30 to 60 percent, by volume, at the gun; however, coatings at the upper end of this range are still experimental.[74-75] Unlike the two-component catalyzed urethanes, there are no pot-life problems associated with single-component acrylics, although some of the higher solids content acrylics are two-component coatings which require the use of an oven bake to completely cure the coating.[73] This additional equipment expense has affected the marketing of the two-component acrylics such that they remain experimental coatings.[73]

3.3.3.3 Waterborne Coatings. Waterborne coatings are routinely used on plastic parts for business machines. Some manufacturers are satisfied with the performance and the appearance of waterborne coatings.[76-78] Others feel that waterborne coatings do not have the adhesion and resistance qualities that are obtained with organic-solvent-based coatings.[17,20,21] Both air atomized and air-assisted airless spray equipment can be used to apply waterborne coatings. Electrostatic air spray equipment can be used if the entire system is isolated from grounded surfaces.[37]

Advantages of waterborne coatings are that they are less flammable and less toxic because of the small amount of organic solvent present in the coatings. Waterborne coatings have some disadvantages, such as increased rust of coating equipment compared to organic-solvent-based coatings. Waterborne coatings do not exhibit the self-cleaning (degreasing) ability that some organic-solvent-based coatings exhibit on parts, which may lead to the need for greater expenditure of time and money in the cleaning process. Waterborne coatings are also more expensive, require longer cure times, and require higher atomization pressures than organic-solvent-based coatings.[6,79] However, some coating manufacturers state that overall finishing costs of waterborne coatings are less than or equal to the overall finishing costs of urethanes.[80]

The most commonly used waterborne coatings are waterborne acrylics, which may represent as much as 10 percent of the coatings applied to plastic parts for business machines. These coatings typically contain no more than 37 percent, by volume, solids as applied (75 percent, by volume, solids minus water). The VOC content of these coatings is usually about 0.24 kg VOC/ℓ of coating (2 lb VOC/gal of coating), minus water, at the gun.[3]

An acid-catalyzed waterborne coating using a proprietary resin has recently been introduced for use on business machine parts. This new coating has a higher solids content (42 percent, by volume) than is possible with waterborne acrylics.[4,80] Its VOC content is estimated at 0.18 kg VOC/ℓ of coating (1.5 lb VOC/gal of coating), minus water, at the gun.[78] The coating is reported to have good adhesion and resistance properties on all plastics, comparing favorably with organic-solvent-based urethanes.[80]

3.3.3.4 Powder Coatings. Powder coatings are not used on plastic parts for business machines because they require curing temperatures that exceed the temperature limitations of the plastic parts.[81] Powder coatings that can be cured with ultraviolet (UV) or infrared (IR) radiation are being developed and, once proven, may be applicable to this industry.[81]

3.4 BASELINE EMISSIONS

The baseline emission level is the level of emission control that would exist for the surface coating of plastic parts for business machines in the absence of a new source performance standard (NSPS).

3.4.1 Existing Emission Regulations

Because there are presently only one State regulation and two local regulations specifically controlling VOC emissions from the surface coating of plastic parts, the baseline emission level for this process cannot be determined from State Implementation Plans (SIP's). Some general solvent handling and surface coating regulations are used by States to limit VOC emissions from the surface coating of plastic parts for business machines, but the majority of States either do not regulate this process or use construction and operating permits to limit emissions.

The State of Missouri and two air pollution control districts in the State of California have proposed regulations that would limit the VOC content of coatings used on plastic parts.[82-84] Only one facility is known to be affected by the Missouri regulation.[83] This facility does not coat business machine parts.

3.4.2 Coating Utilization

Because of the lack of State regulations controlling the surface coating of plastic parts, the baseline emission level was determined through the use of coating consumption data obtained from this industry. Because no add-on emission control devices are used in this industry, VOC emissions are a function of coating formulation and coating consumption.

Information in the literature and from contacts with coaters of plastic parts for business machines show that organic-solvent-based coatings containing about 30 percent, by volume, solids as applied are the most commonly used exterior coatings.[4-13,18,41,42] Organic-solvent-based exterior coatings containing roughly 50 percent, by volume, solids as applied are also being used.[4-13,18,41,42] Organic-solvent-based nickel-filled acrylics containing about 15 percent, by volume, solids as applied are the most commonly used organic EMI/RFI shielding coatings.[4-13,18,40] Altogether, organic-solvent-based coatings represent at least 90 percent of the organic coatings applied to plastic parts for business machines.[4-13,18,41,42] The remaining 10 percent is made up of waterborne coatings, most of which contain about 37 percent, by volume, solids and about 13 percent, by volume, VOC as applied.[4-13,18,41,42]

Coating consumption data for typical plants appear in Table 3-2. These data represent the baseline condition, or the coating consumption that would be expected in the absence of an NSPS.

TABLE 3-2. COATING UTILIZATION OF A TYPICAL PLANT

Type of coating	Percent solids, by volume, at the gun	Percent of total coating consumption	VOC content[a] kg/ℓ coating (lb/gal of coating less water	VOC content[a] kg/ℓ of solids (lb/gal of solids)
Solvent-based EMI/RFI shielding coating	15	17.1	0.75 (6.3)	5.00 (42.0)
"Lower solids" solvent-based coating	32	53.7	0.60 (5.0)	1.87 (15.6)
"Medium solids" solvent-based coating	50	19.5	0.44 (3.7)	0.88 (7.3)
Waterborne coating (water/VOC = 80/20)	37	9.7	0.22 (1.9)	0.30 (2.5)

[a] Assuming an average solvent density of 0.882 kg/ℓ (7.36 lb/gal).

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4. EMISSION CONTROL TECHNIQUES

This chapter describes techniques that are available to control volatile organic compound (VOC) emissions from the surface coating of plastic parts for business machines. The control techniques discussed are the use of lower-VOC-content coatings, process modifications, and add-on controls.

VOC emissions occur when organic solvents evaporate from coatings that are used to finish the parts. Commonly used organic solvents include ketones, esters, ethers, and saturated and unsaturated hydrocarbons. VOC emissions also may occur as by-products of reactions that take place as the coatings cure.

Assuming that 100 percent of the organic solvent sprayed evaporates into the atmosphere, a materials balance approach can be used to estimate VOC emissions from the coating process. Although no direct VOC emission data are available for the individual steps in the spray-coating process, estimates can be made of VOC emissions from various stages in the surface coating process. Based on an average transfer efficiency of 25 percent for the spray coating step, at least 75 percent of the VOC is emitted in the spray booth due to overspray alone. Assuming that an additional 5 percent of the VOC evaporates in the booth from coating that adheres to parts, a total of about 80 percent of the VOC is emitted in the spray booth. The remaining 20 percent of VOC emissions occur in flash-off areas and curing ovens. These estimates are comparable to estimates that have been made for analogous coating lines in other industries.[1-2] In Southern California, for example, the South Coast Air Quality Management District (SCAQMD) found that almost 90 percent of the VOC emissions from surface coating operations occur in the spray booth and/or the flash-off area.[1] Similarly, for the spray-coating of large appliances, an estimated 80 percent of the VOC emissions occur in the spray booth and flash-off area.[2]

The average transfer efficiency for the spray coating of plastic parts is lower than it is for the spray coating of metal parts, which is often done electrostatically; thus, more VOC is emitted in the spray booth for plastic parts due to the increased overspray. Furthermore, coatings applied to plastic parts must be able to dry at lower temperatures, so they often contain lower boiling solvents than coatings for metal parts. The rapid evaporation of these lower boiling solvents in the spray booth and flash-off area means that only a small portion of the VOC is emitted in the curing oven. For these reasons, the proportion of VOC emissions occurring in the spray booth is greater at facilities that coat plastic than at facilities that coat metal.

4.1 USE OF LOWER-VOC-CONTENT COATINGS

Emissions can be reduced by using coatings that contain less VOC than conventional coatings. Examples of coatings in which the VOC content is lower than that in conventional organic-solvent-based coatings are:

1. Organic-solvent-based coatings containing $\geq$40 percent, by volume, solids as applied, and
2. Waterborne coatings.

Exterior decorative/protective coatings and electromagnetic interference/radio frequency interference (EMI/RFI) shielding coatings are available in lower-VOC-content forms. The advantages and disadvantages of these coatings are discussed in the following sections.

4.1.1 Lower-VOC-Content Organic-Solvent-Based Exterior Coatings

Organic-solvent-based two-component catalyzed urethane coatings containing between 40 and 54 percent, by volume, solids at the gun are currently being used to coat plastic parts for business machines.[3-7] The performance and ease of application of these coatings has been demonstrated on the major types of plastics used in business machines, as well as on metal parts.[3] These coatings possess the same good adhesion and durability as do the popular, lower solids urethane coatings that contain less than 40 percent, by volume, solids as applied.[3-5,8] For some of these coatings, color and texture coats can often be applied without using a primer.[3,8] The major disadvantage of these urethanes is their limited pot life, which ranges from 1 to 4 hours once the coating and catalyst are mixed.[3-5,8] Metering systems are available that can alleviate this problem by drawing the coating and the catalyst from separate reservoirs and mixing them at or prior to the spray gun.

Two-component catalyzed urethane coatings containing at least 60 percent, by volume, solids at the gun have been successfully used to coat polystyrene (PS), polycarbonate (PC), polyphenylene oxide (PPO), steel, and aluminum business machine parts, but are not currently being used in production.[9-14] Polystyrene (PS), which is sensitive to solvent attack, has been coated with the higher solids urethane without applying a protective waterborne primer as is commonly done when solvent-based urethanes containing less than 60 percent, by volume, solids are used.[11,12,15] Significant reductions in production costs were possible when higher solids coatings were used, because parts that previously required three coats (prime coat, base or color coat, and texture coat) were successfully finished using only two coats (base or color coat and texture coat).[3,12,15] Furthermore, surface preparation steps, including sanding and filling, were deleted.[4,5,8] The decrease in processing steps resulted in decreased labor and materials costs and higher production rates.[12] Also, each part was coated with fewer passes of the spray gun, resulting in faster production. Use of these coatings substantially reduced VOC emissions because they contained about 0.35 kg VOC/ℓ of coating (3.0 lb VOC/gal of coating) as sprayed, compared to 0.60 kg VOC/ℓ of coating (5.0 lb VOC/gal of coating) for the conventional urethane coatings. These coatings were recently reformulated to a lower volume solids content of about 53 percent at the gun to extend their pot life without using plural component metering equipment.[13]

Another two-component catalyzed urethane coating containing approximately 60 percent, by volume, solids at the gun is currently in the experimental stage, and is being tested by several OEM's.[16] The long pot life of this coating (8 to 16 hours) allows this coating to be sprayed without using plural component metering equipment.

The major disadvantage of using higher solids urethane coatings is that they may require the use of plural-component metering systems and pumps that can generate 0.014 to 4.2 mPa (2 to 600 psi) fluid pressure.[3-5,9-12,15,17] Without a plural-component metering system, the pot life of some of these coatings is less than an hour. Due to the technical nature of the equipment, some coaters have experienced difficulty in getting these systems to operate properly or have experienced maintenance problems with them.[17,18] Another disadvantage with these coatings is that spray operators must be specially trained to use the plural-component metering system in applying higher solids coatings at the desired film thickness.[19] Also, as the solids content is increased, larger quantities of isocyanates are required, which may increase worker exposures to isocyanates.[19]

A single-component organic-solvent-based acrylic thermoset coating containing between 50 and 55 percent, by volume, solids at the gun (about 0.42 kg VOC/ℓ of coating [3.5 lb VOC/gal of coating]) is being used experimentally on both plastic and metal business machine parts.[4,20-22] This coating can be sprayed with conventional spray equipment and can be cured by baking for 15 minutes at 60°C (140°F), followed by 30 to 40 minutes drying at room temperature.[21] It has been successfully used to coat PPO, PC, other structural foams, and metals on experimental coating lines, but production scale tests have not yet been performed.[4,20-22] The coating does not contain the isocyanate catalysts that are used in two-component urethane coatings, so use of this coating is one way to avoid exposing workers to isocyanates.[4,22] This coating can be used without a plural-component metering system because its pot life is longer than that of the higher solids urethane coatings.

A single-component organic-solvent-based urethane coating containing between 50 and 55 percent, by volume, solids at the gun (about 0.42 kg VOC/ℓ of coating [3.5 lb VOC/gal of coating]) has been tested on steel and plastic.[23] This coating can be sprayed with conventional spray equipment and must be baked between 20 and 40 minutes at 60°C (140°F). It does not require the plural-component metering equipment that is needed to apply some two-component urethane coatings.[23]

A two-component organic-solvent-based acrylic thermoset coating containing approximately 60 percent, by volume, solids at the gun (about 0.34 kg VOC/ℓ of coating [2.8 lb VOC/gal of coating]) is being tested by several OEM's.[24,25] This coating can be sprayed with conventional spray equipment and must be baked for a minimum of 30 minutes at 60°C (140°F). It has been successfully applied experimentally to many types of plastic, but has limited use on metals.[24] A major problem with the marketing of this coating is the required bake period; many coaters have limited, if any, bake facilities.[24]

It is not possible to apply uniform thin films (<0.5 mil) of the higher solids coatings discussed above because of the difficulty, relative to lower solids coatings, of spraying the small volume of coating required per unit area. Therefore, higher solids coatings are not being used for fog coating of parts with molded-in color and texture.

4.1.2 Lower-VOC-Content Organic-Solvent-Based EMI/RFI Shielding Coatings

An organic-solvent-based nickel-filled acrylic coating containing 25 percent, by volume, solids at the gun is available for application to business machine housings to provide EMI/RFI shielding.[27] The manufacturer recommends it for use on modified PPO, foamed styrene, and PC. Because of the high density of the nickel pigment, the coating is agitated during application to prevent settling.[27]

An organic-solvent-based nickel-filled two-component catalyzed urethane coating containing 25 percent, by volume, solids at the gun is available for application to business machine housings to provide EMI/RFI shielding.[28] Nickel-filled urethane coatings provide a more durable finish than nickel-filled acrylic coatings and, therefore, are less susceptible to chemical or physical damage that could result in reduced EMI/RFI shielding effectiveness.[4,28,29]

4.1.3 Waterborne Exterior Coatings

Waterborne exterior decorative/protective coatings that can be cured at low temperatures are presently used on some plastic business machine parts, although they are not as commonly used as organic-solvent-based coatings. Waterborne coatings are being used to coat structural foam parts that require substantial coating films and to coat straight-injection-molded parts with molded-in color and texture that require films of 0.5 mil or less. Several large business machine manufacturers have approved waterborne coatings for use on their products.[30-33]

The advantages attributed to waterborne coatings include reduced fire hazards, ability to coat nonconductive substrates electrostatically, easy cleanup, and the low cost and availability of the diluting solvent, water.[30,34,35] Waterborne coatings can be applied using air atomized, air-assisted/airless, and electrostatic spray equipment.[17,30,34,35]

There are disadvantages associated with the use of waterborne coatings. Because water is corrosive, rustproof spray equipment, usually stainless steel, is recommended for use with waterborne coatings.[36] Higher atomization pressures are required to spray waterborne coatings than to spray solvent-based coatings, and this may result in lower transfer efficiencies.[5,18] Some coaters and coating manufacturers have indicated that compared to organic-solvent-based coatings, waterborne coatings are more expensive to use.[3,8] In addition, waterborne coatings dry more slowly than organic-solvent-based coatings due to slower evaporation rates.[37] This could lead to process problems if an applicator were air-drying coated parts instead of using ovens.

The performance of waterborne coatings compared to organic-solvent-based coatings is debated by coaters and coating manufacturers. Many coaters feel that the adhesion, durability, and gloss of waterborne coatings are inferior to that achieved with solvent-based coatings.[4,8,9,15,38] For some coaters the quality of the finish obtained with waterborne coatings is acceptable, but for others it is not.[9,15,30-34]

The two major types of waterborne coatings presently used on plastic parts for business machines are acid-catalyzed waterborne coatings and waterborne acrylic emulsions. The resin used in the acid-catalyzed coating is considered confidential by the manufacturer.[39] The acrylic coatings have been available longer and are more frequently used than the acid-catalyzed coatings.[4] The acrylic coatings usually contain no greater than 37 percent, by volume, solids as sprayed and about 0.24 kg VOC/ℓ of coating (~2.0 lb VOC/gal of coating), less water. The newly marketed, acid-catalyzed waterborne coating contains a higher solids content than do the waterborne acrylics.[4] Its VOC content is estimated at about 0.18 kg VOC/ℓ of coating (1.5 lb VOC/gal of coating) at the gun.[33] This coating is reported to have good adhesion and resistance properties on plastic that compare favorably to the adhesion and resistance properties of solvent-based urethanes.[4,33]

4.1.4 Waterborne EMI/RFI Shielding Coatings

Waterborne nickel-filled acrylic EMI/RFI shielding coatings are available for application to business machine housings.[40-45] One coating is available that contains 0.23 kg VOC/ℓ of coating (1.9 lb VOC/gal of coating), less water and about 34 percent, by volume, solids as applied.[46] This coating has been approved by Underwriters Laboratories for its adhesion to plastic.[47] Another coating is available that contains 0.32 kg VOC/ℓ of coating (2.71 lb VOC/gal of coating), less water and about 32 percent, by volume, solids as applied.[41] This coating has shown excellent adhesion to most plastics, but is particularly effective on thermoplastics such as PS, ABS, PC and PPO.[48] Other coatings are available that contain approximately 30 to 32.5 percent, by volume, solids as applied.[42,43] One of these coatings is being used in production for application on injection-grade Lexan, and the other coating can be applied to ABS, PC, and certain grades of Lexan.[42,44,45] As noted earlier, waterborne coatings require longer drying periods than organic-solvent-based coatings. None of these coatings are widely used.

4.2 PROCESS MODIFICATIONS

Process modifications that might be used to reduce VOC emissions from the surface coating of plastic parts for business machines are discussed in this section. The two major types of process modifications to reduce VOC emissions are improvements in transfer efficiency and the use of surface finishing techniques that do not emit VOC.

4.2.1 Transfer Efficiency

Transfer efficiency is defined to be the ratio of the amount of coating solids deposited on the surface of the coated part to the total amount of coating solids sprayed. Improved transfer efficiencies result in less overspray. Consequently, total coating consumption is reduced, resulting in decreased VOC emissions. Transfer efficiencies can be improved by using an application technique other than spray application, such as dip coating, or by using a more efficient spray technique such as air-assisted airless spraying or electrostatic spraying instead of conventional air atomized spraying. Transfer efficiencies can also be improved by proper operation and maintenance of spray equipment, and by manipulation of various operating parameters such as spray booth air flow (within allowable limits dictated by regulatory and safety considerations). Application techniques other than spray coating are rarely used for coating plastic business machine parts, so they will not be discussed. Air-assisted airless spraying and electrostatic air spraying, which are demonstrated process modifications for improving transfer efficiency, are discussed below.

4.2.1.1 Air-Assisted Airless Spray. Air-assisted airless spray was originally developed for use in the furniture finishing industry, but it is also in use at facilities that surface coat plastic parts for business machines.[17,49,50] In this technique, coating is atomized without air by being forced through a specially designed nozzle. Further atomization is achieved by the introduction of a low-pressure air stream. The resulting spray is slower and less turbulent than that provided by air spray, thus transfer efficiency is improved. With regard to exterior coatings, air-assisted airless spray can achieve a transfer efficiency of 40 percent, as compared to 25 percent for conventional air spray.[51]

The main advantages of this technique are materials savings and reduced VOC emission rates. Disadvantages include a higher capital investment for equipment and the need to train spray operators to use the equipment properly. Although air-assisted airless spray equipment has been used in production at many facilities, it has not been used for application of the higher solids two-component catalyzed urethane coatings or for application of the texture coat.[51] Also, one company has reported difficulty in using it with conventional coatings.[37]

4.2.1.2 Electrostatic Air Spray. The limited use of electrostatic spray coating for plastic parts used in business machines reflects the difficulty of coating a nonconductive surface electrostatically. To use electrostatic spray, the surface of the plastic part must be made conductive so that a voltage difference can be maintained between the atomized coating and the part being coated. This is usually achieved by charging the atomized paint and grounding the part so that the coating is attracted to the part by electrostatic force. Atomization of the coating can be achieved by air, airless, air-assisted airless or rotary techniques. Only air atomized electrostatic spray methods have been demonstrated for application of coatings to plastic parts for business machines.[52,53]

In general, the major benefits attributed to electrostatic spraying are reduced coating consumption and reduced VOC emissions due to increased transfer efficiency. Transfer efficiencies achieved by electrostatic spray techniques are reported to be from 30 to 90 percent, depending on the type and shape of the part, the type of atomization, and the type of coating.[53,54] Transfer efficiency is generally higher for an automated system than for a manual one, although automatic systems are only practical for long coating runs of similar parts.[55,56] The transfer efficiency of electrostatic air spray is assumed to be at least as high as that of air-assisted airless spray, that is, at least 40 percent.[57]

Disadvantages of electrostatic air spraying include increased capital costs for special equipment and the presence of electrical hazards for spray operators. In addition, touch-up coating is often necessary due to the Faraday Effect.[58] This is an electrostatic repulsion phenomenon that prevents charged coating particles from entering recessed areas on parts being coated. Since plastic parts, and particularly structural foam parts, are especially useful when complex shapes with many recesses are needed, the Faraday Effect may be a significant problem. Simple shapes, which are less susceptible to the Faraday Effect, are frequently more practical to form from metal.[58]

Electrostatic air spray coating of plastic business machine parts is being accomplished in two ways. One method involves the application of a conductive sensitizer to the plastic part before electrostatic application of subsequent coats of paint.[59] The conductive sensitizer is typically an organic-solvent-based or waterborne salt solution that is applied by dip coating, spray coating, or manual wiping onto the plastic part. When the solvent evaporates, the hydrophilic salt attracts moisture from the atmosphere and forms a conductive layer on the surface of the plastic part. Up to four coats can then be applied electrostatically.[60] Although application of an organic-solvent-based conductive sensitizer would emit VOC, use of electrostatic air spray in applying subsequent top coats would still reduce overall VOC emissions.[57]

Another method that is currently being used to prepare plastic parts for electrostatic air spray application of decorative/protective coatings is electroless deposition of a thin film of metal onto the surface of the plastic part.[55,61-63] Electroless plating is used primarily for the purpose of EMI/RFI shielding and is described in Section 4.2.2.2.2. This EMI/RFI shielding technique deposits a film of metal on all exposed surfaces of a plastic part (i.e., both interior and exterior surfaces). The surface of the plastic is rendered conductive and can be top-coated electrostatically.[55,61-63]

Methods that have been used in other industries to spray coat plastic parts electrostatically include the use of conductive (waterborne) coatings, the placement of a grounded metal image behind the part being painted, and the deposition of a thin film of metal from the vapor phase onto the plastic part by vacuum metallizing or sputtering prior to electrostatic air spray coating.[32,64,65] Although all of these techniques appear to be feasible approaches to electrostatic air spray coating, they have not been used for production coating of plastic business machine parts.

Other potential ways of coating plastic parts electrostatically include the grounding of the EMI/RFI shielding coating on the interior surface of plastic housings, the use of the EMI/RFI shielding coating as a conductive primer that is applied to the exterior surface of plastic housings and grounded during electrostatic top-coating, and the use of conductive plastics. Some of these techniques are being studied experimentally but have not been used in production.[54]

The grounding of the EMI/RFI shielding coating on the interior surface of the plastic part would be analogous to using a grounded metal image behind the plastic part being coated. The effectiveness of this technique depends on the conductivity of the EMI/RFI shielding material and the uniformity of the EMI/RFI shielding coating film.[54]

The feasibility of applying the EMI/RFI shielding coating to the exterior surface of plastic housings to serve as a conductive primer has not been evaluated.[29,66] To serve this dual purpose, the conductive coatings would have to be chemically compatible with subsequent top coats.[28,29,67] For example, if the organic-solvent-based nickel-filled acrylic lacquer coatings that are now commonly applied to housing interiors were used as conductive exterior primers, they would be sensitive to attack by some solvents present in subsequent top coats.[29] This solvent attack could lower the EMI/RFI shielding effectiveness of the coating.[28,29] Organic-solvent-based nickel-filled urethane coatings would probably be more successful as conductive exterior primers because they have greater chemical resistance; however, the urethane coatings are more expensive than the acrylic coatings.[28,29]

4.2.2 Surface Finishing Techniques That Do Not Emit VOC

Another type of process modification that can be implemented to reduce VOC emissions is to use surface finishing techniques that do not emit VOC. Finishing methods that do not emit VOC exist both for exterior decorative applications and for EMI/RFI shielding applications.

4.2.2.1 Exterior Decorative Finishing. The major non-VOC-emitting technique employed to provide an attractive finish on plastic parts used in business machines is the use of molded-in color and texture. This method relies on the use of straight injection molding techniques in which pigment is added to the resin before or during the injection molding step to provide the desired color. Molded-in texture requires that the mold itself be tooled in such a way as to provide the desired raised texture pattern on the molded parts. Parts with molded-in color and texture cannot be produced using structural foam injection molding.

The use of molded-in color and texture is the method of choice for some producers of plastic parts for business machines.[68-71] Some manufacturers have reported significant savings by substituting the use of molded-in color and texture for surface coating processes.[70] Others feel that the technology of molded-in color and texture does not provide satisfactory color reproducibility and color stability, and does not protect the plastic parts from environmental stress.[9,15,72] Some coaters report that plastic parts with molded-in color and texture still require some surface coating.[4,15] If too much coating is applied, however, the molded-in texture may be masked.

Cost considerations also influence the use of molded-in color and texture. The mold used for straight injection molding is more expensive than the mold used for structural foam injection molding. The reduction in finishing costs realized by using molded-in color and texture (a straight injection molding process) must, therefore, offset the higher cost of the mold. The cost considerations affecting this choice are complex and depend upon many factors including the size of the part, the complexity of the shape of the part, and the number of parts produced from the mold.

4.2.2.2 EMI/RFI Shielding. EMI/RFI shielding techniques that do not emit VOC include zinc-arc spraying, electroless plating, the use of conductive plastics, the use of metal inserts, and in some cases, vacuum-metallizing and sputtering. Considerations other than VOC emissions greatly influence the EMI/RFI shielding techniques used. Two important considerations are shielding effectiveness and cost of a given technique. Cost factors are discussed in Chapters 8 and 9. Simple comparisons of EMI/RFI shielding effectiveness cannot be made among the different shielding techniques. Shielding effectiveness depends upon the type of material used for shielding, coating thickness, coating uniformity, and the frequency of the EMI/RFI signals.

4.2.2.2.1 Zinc-arc spraying. Zinc-arc spraying is a two-step process in which the plastic surface is roughened by sanding or grit-blasting, and a coating of molten zinc is sprayed onto the roughened surface. Advantages to zinc-arc spraying include high shielding effectiveness over a wide range of frequencies and the fact that it is a widely demonstrated EMI/RFI shielding technique. Disadvantages include the need for special equipment such as a zinc-arc spray gun, a spray gun air supply, a face shield and breathing air supply or respirator for the operator, hearing protection, and a waterwash spray booth or baghouse dust collector.[73,74]

4.2.2.2.2 Electroless plating. Electroless plating is a dip process in which a film of metal is deposited from aqueous solution onto all exposed surfaces of the part. The plastic parts are prepared for electroless plating by oxidizing their surfaces with aqueous chromic and sulfuric acids or with gaseous sulfur trioxide (SO_3). Following the oxidizing step, a metal film (usually copper, nickel, or chrome) is electrolessly plated onto the plastic part.[63,75] Advantages of electroless plating include the ability to coat the plated parts electrostatically, low materials and labor costs, and good shielding effectiveness.[55,61-64] One disadvantage is the incompatibility of electroless plating with molded-in color unless masking is used. Another disadvantage is the potential for VOC emissions if coatings that emit VOC's are applied prior to the plating step so that only selected areas of the parts are plated.[76]

4.2.2.2.3 Conductive plastics. Conductive plastics, which are mixtures of resins and conductive fillers, are not widely used for EMI/RFI shielding at the present time.[77] These materials are being studied extensively for their usefulness in business machine applications, and some conductive plastics are already being used to make business machine enclosures.[77,78] Available resin types include ABS, ABS/PC blends, PPO, nylon 6/6, polyvinyl chloride, and polybutyl terephthalate. Conductive fillers include aluminum, steel, metallized glass, and carbon. Advantages of using conductive plastics include elimination of the EMI/RFI shielding finishing step and improved resistance to warping. Disadvantages include high materials cost, less effective EMI/RFI shielding especially when structural foam molding is used, and the addition of a cosmetic finishing step to improve the surface appearance.[78-80]

4.2.2.2.4 Metal inserts. The use of metal inserts to house electronic components within a plastic housing is a demonstrated EMI/RFI shielding technique. The metal insert can be in the form of a metal box within a plastic housing, metal foil laminated between layers of compression molded plastic, metal foil glued inside the housing, or metal screens or fibers placed within a plastic housing. Shielding effectiveness is comparable to that obtained with metal housings.

4.2.2.2.5 Vacuum-metallizing or sputtering. Vacuum-metallizing and sputtering are two similar techniques in which a thin film of metal is deposited onto the plastic substrate from the vapor phase. Although no VOC emissions occur during the actual metallizing process, solvent-based prime coats and top coats are often sprayed onto parts to promote adhesion and prevent degradation of the metal film. The VOC emission reduction potential of these techniques depends on the extent to which VOC-containing prime coats and top coats are used, and the VOC content of the coatings used. A disadvantage of these techniques is the need to purchase additional equipment.

4.3 EMISSIONS CONTROL WITH ADD-ON CONTROL EQUIPMENT

Add-on control equipment such as carbon adsorbers, incinerators, and condensers are presently being used to control VOC emissions at many surface coating facilities, including magnetic tape coaters, fabric coaters, and automobile coaters.[81-83] No add-on control devices are currently used by facilities that surface coat plastic parts used in business machines. Most of the solvent-laden air (SLA) in these facilities comes from the application/flash-off area. The concentration of VOC in this air is very low because it must be diluted to protect workers from breathing harmful levels of organic solvents, isocyanates, and overspray. The amount of VOC in the air exhausted from the curing ovens is low because about 90 percent of the solvent evaporates before the coated parts enter the oven. Ovens can be operated at greater than 25 percent of the lower explosive limit (LEL) to minimize the costs of operation and emissions control; however, only 10 percent of the total emissions can be reduced by ducting oven emissions to a control device.[84]

The SLA from the application/flash-off area can be captured and ducted to a control device, but the high volume of air and the low concentration of VOC make this a costly method of control. For example, the cost of using a thermal incinerator with primary heat recovery to control VOC emissions from the spray booths and flash-off areas for a medium-sized model plant (as defined in Chapter 6) is estimated to be $11,000 to $21,000 per Mg ($10,000 to $19,000 per ton) of VOC controlled. The specific cost depends on the booth ventilation rate.[85]

Although add-on control devices are not in use at facilities that coat plastic parts for business machines, the general principles behind carbon adsorption, incineration, and condensation are discussed in this section.

4.3.1 Carbon Adsorption

Carbon adsorption uses a bed of activated carbon to remove organic vapors from an incoming airstream. The mechanism of VOC removal is complex, but the removal efficiency is enhanced by specific characteristics of the carbon. Its high surface-to-volume ratio and its affinity for organics make activated carbon an effective adsorbent of VOC.[86] The VOC adsorption efficiency across a carbon bed can be at least 95 percent if it is properly maintained and if VOC concentration levels are sufficiently high.[87]

After a carbon bed has adsorbed a certain amount of VOC, a breakthrough is reached beyond which the VOC removal efficiency decreases rapidly. The bed must be regenerated before the breakthrough is reached, otherwise saturation will occur and removal efficiency will become zero. Typically, a carbon bed is regenerated by passing steam through the carbon, countercurrent to the regular air flow, to strip the solvent from the carbon. The effluent is condensed and then separated from the residual water by decantation. The collected solvent may be reused, sold, or disposed of as hazardous waste.

Figure 4-1 shows a typical carbon adsorption system.[86] The two-bed configuration allows for continuous operation of the coating facility because one adsorber can be regenerated while the other is on-line.

4.3.2 Incineration

The two main types of incineration are thermal incineration and catalytic incineration.

4.3.2.1 Thermal Incineration. A schematic diagram of a thermal incinerator is shown in Figure 4-2.[88] In this particular design, the SLA is pre-heated by primary heat exchange with waste heat from the combustion chamber. A burner is supplied with additional fuel that ignites the pre-heated air stream. This process converts the incoming VOC to carbon dioxide and water vapor.

Three important design considerations of the combustion chamber are time, temperature, and turbulence. The residence time, which must be sufficient to permit complete combustion of the VOC, is about 0.2 to 0.8 seconds. The necessary temperature range for thermal incineration is 760° to 870°C (1400° to 1600°F). Turbulence facilitates the mechanical

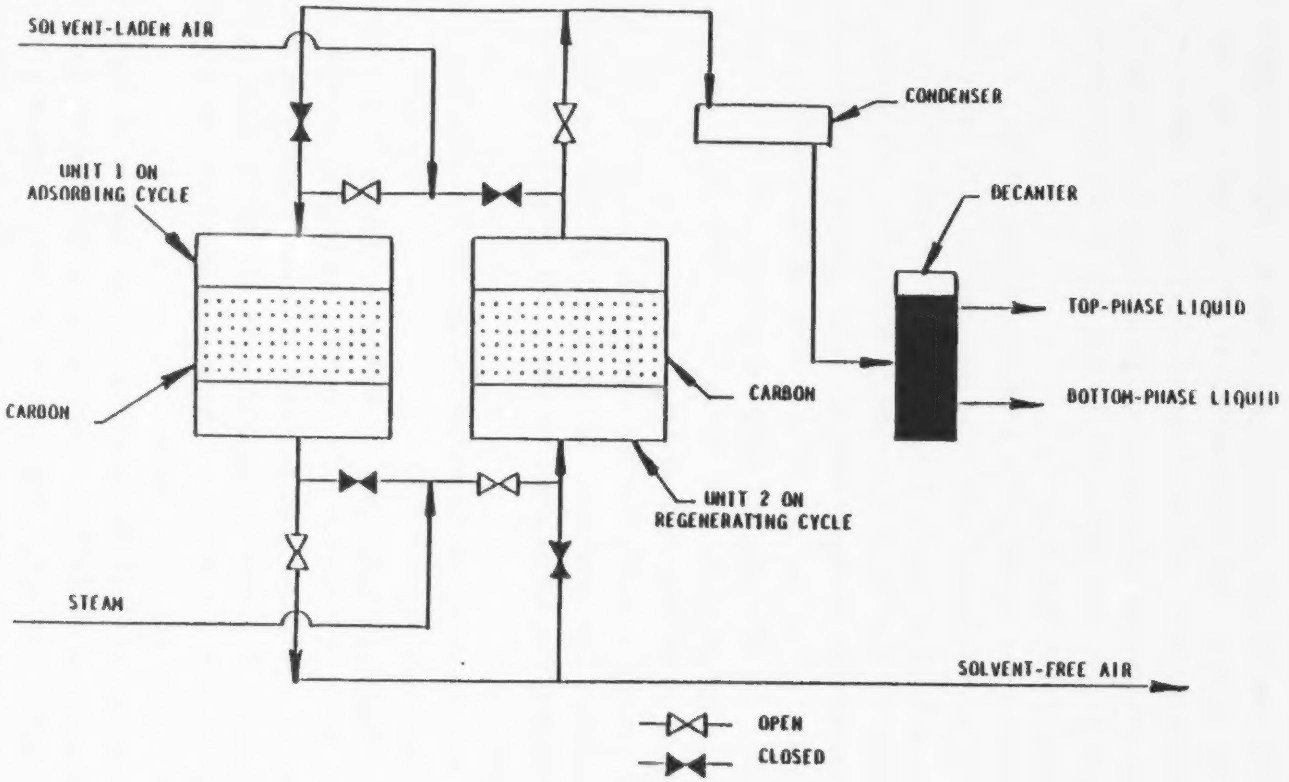
SOLVENT-LADEN AIR
UNIT 1 ON ADSORBING CYCLE
CARBON
STEAM
CARBON
UNIT 2 ON REGENERATING CYCLE
CONDENSER
DECANTER
TOP-PHASE LIQUID
BOTTOM-PHASE LIQUID
SOLVENT-FREE AIR
OPEN
CLOSED

Figure 4-1. Two-unit, fixed-bed carbon adsorption system.

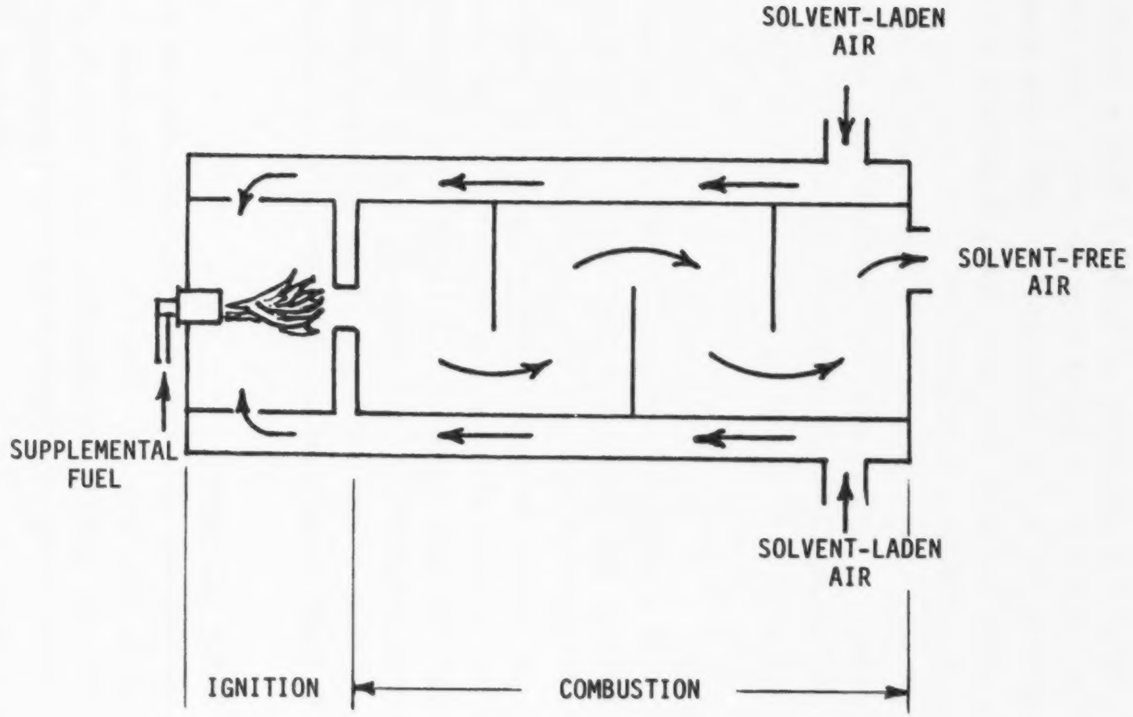
SOLVENT-LADEN AIR
SOLVENT-FREE AIR
SUPPLEMENTAL FUEL
SOLVENT-LADEN AIR
IGNITION
COMBUSTION

Figure 4-2. Diagram of thermal incinerator.

mixing of oxygen, heat, and VOC necessary for maximum destruction efficiency.[88] A properly designed incinerator can achieve destruction efficiencies of 98 percent if VOC concentration levels are sufficiently high.[89]

4.3.2.2 Catalytic Incineration. Figure 4-3 shows a typical catalytic incinerator. The SLA enters the device from the oven or application area. It is preheated to 260° to 460°C (500° to 860°F) and blown across a catalyst site where oxidation occurs.[88] About 98 percent of the incoming VOC can be removed in this manner.[89]

The catalyst accelerates the rate of oxidation without undergoing a chemical change itself. Typical materials used are noble metals, such as platinum or palladium, dispersed on an alumina support. Combustion temperatures are lower for catalytic incinerators than for thermal incinerators.

4.3.3 Condensation

Condensation is a method of capturing VOC emissions by cooling solvent-laden gases to the dew point of the solvent and collecting the liquid droplets. Liquid nitrogen and air are typical coolants used in the shell and tube surface condenser shown in Figure 4-4. Heat is extracted from the incoming air stream as it passes through the cooled metal tubes. When the vapor condenses, it is collected and either reused or discarded, depending on its purity.[90] Removal efficiencies are comparable to those of the previously discussed add-on devices if the condenser is properly designed and VOC levels are sufficiently high.[86]

4.4 EMISSION SOURCE TEST DATA

There are no data available on control equipment because no add-on controls are used in this industry. There is no single point to which all emissions from the facility are exhausted; thus, there is no point at which measurements of VOC concentration would be representative of the facility as a whole.

Total VOC emissions can be estimated using a materials balance approach that assumes all of the VOC sprayed evaporates into the atmosphere. Emissions can be estimated for various steps in the surface coating

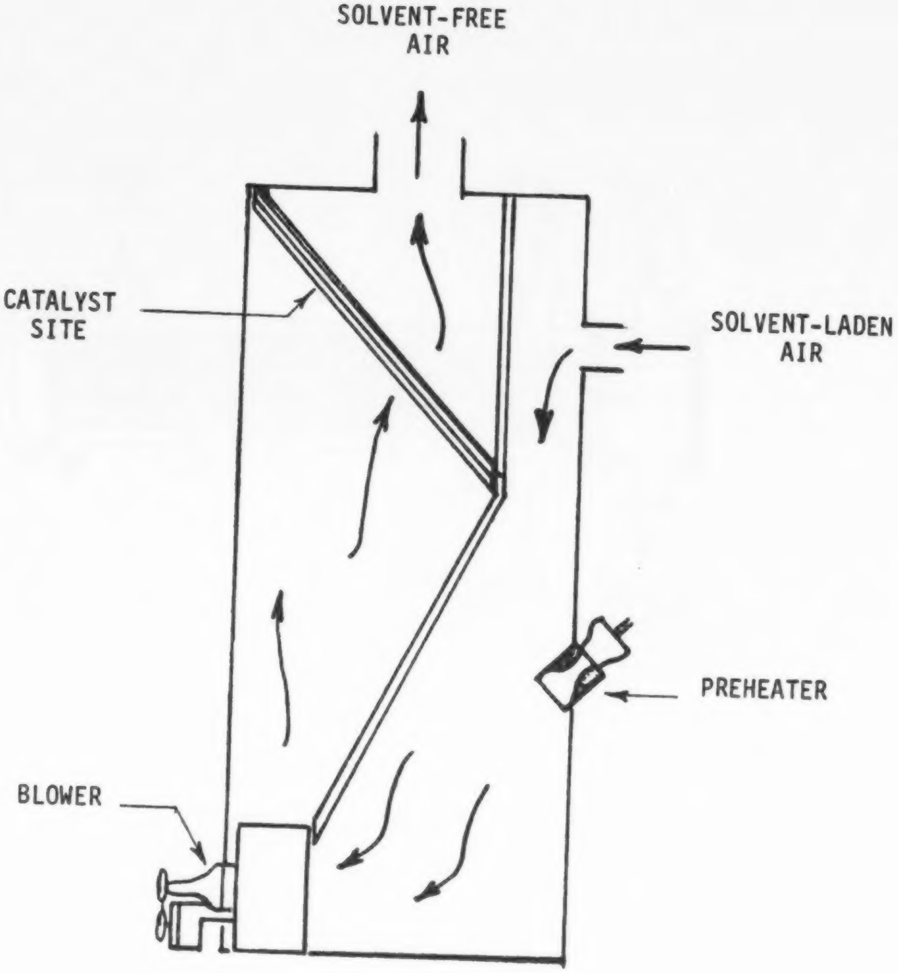
SOLVENT-FREE AIR
CATALYST SITE
SOLVENT-LADEN AIR
PREHEATER
BLOWER

Figure 4-3. Catalytic incinerator

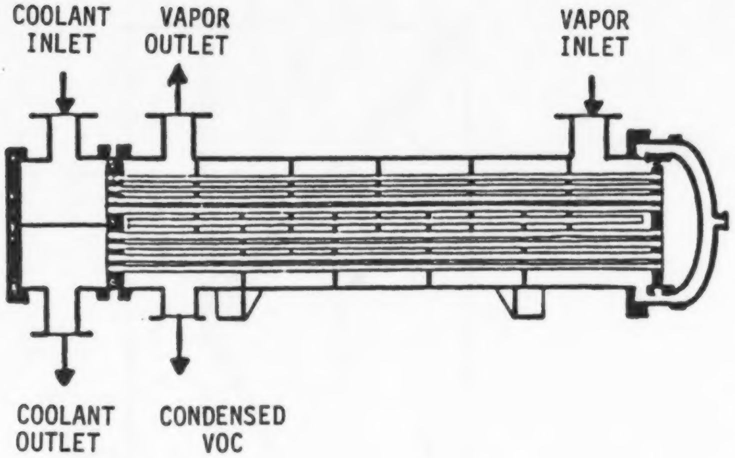
COOLANT INLET
VAPOR OUTLET
VAPOR INLET
COOLANT OUTLET
CONDENSED VOC

Figure 4-4. Shell and tube surface condenser.

process. For example, if an average transfer efficiency of 25 percent is assumed, then at least 75 percent of the total VOC emissions occur in the spray booth during the spray application step. On the average, it is estimated that about 80 percent of the VOC emissions occur in the spray booths, about 10 percent occur in the flash-off areas, and the remaining 10 percent occur in the curing ovens.

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5. MODIFICATION AND RECONSTRUCTION

New source performance standards promulgated in accordance with Section 111 of the Clean Air Act, as amended, apply to all "affected facilities" within the specified industry. Affected facilities include those that commence construction after the proposal date of the standard, as well as existing facilities that are modified or reconstructed after the proposal date. The objective of this chapter is to clarify the conditions under which an existing facility becomes an affected facility. The following sections define "modification" and "reconstruction," as put forth in the Code of Federal Regulations, and present examples of these processes by which an existing facility becomes subject to the performance standards.

5.1 GENERAL PROVISIONS FOR MODIFICATION AND RECONSTRUCTION

5.1.1 Definition of Modification

Section 40 CFR 60.14(a) defines modification as follows:

> Except as provided under paragraphs (e) and (f) of this section, any physical or operational change to an existing facility which results in an increase in the emission rate to the atmosphere of any pollutant to which a standard applies shall be considered a modification within the meaning of Section 111 of the Act. Upon modification, an existing facility shall become an affected facility for each pollutant to which a standard applies and for which there is an increase in the emission rate to the atmosphere.

Paragraph (b) specifies what constitutes an increase in emissions and that methods to determine emission rate include the use of emission factors, material balances, continuous monitor data, and manual emission tests. Paragraph (c) affirms that the addition of an affected facility to a stationary source does not by itself subject any other facility within that source to the performance standards.

Paragraph (e) lists the following physical and operational changes which are not considered to be modifications:

1. Routine maintenance, repair and replacements.
2. Increase in production rate without capital expenditures.
3. Increase in hours of operation.
4. Use of alternative fuel or raw material if, prior to proposal of the standard, the facility was designed to accommodate that alternative use.
5. The addition or use of an emission control device which would result in decreased emissions from the facility.
6. Relocation or change in ownership of an existing facility.

Paragraph (f) allows for special provisions to be set forth, which would supercede any conflicting provisions in this section. Paragraph (g) sets a 180-day time period within which modified or reconstructed facilities must achieve compliance with the promulgated standards.

5.1.2 Definition of Reconstruction

Section 40 CFR 60.15(b) defines reconstruction as follows:

> An existing facility, upon reconstruction, becomes an affected facility, irrespective of any changes in emission rate. "Reconstruction" means the replacement of components of an existing facility to such an extent that: (1) the fixed capital cost of the new components exceeds 50 percent of the fixed capital cost that would be required to construct a comparable entirely new facility, and (2) it is technologically and economically feasible to meet the applicable standards set forth in this part.

The purpose of the reconstruction portion of the regulation is to prevent an owner or operator from continuously replacing a few components of an operating process except for support structures, frames, housing, etc., in an attempt to avoid becoming subject to new source performance standards.

5.2 APPLICABILITY TO SURFACE COATING OF PLASTIC PARTS

In this section, the definitions of modification and reconstruction are applied to specific examples of process changes which may occur at a facility. The definitions and accompanying provisions are used to determine whether or not each change would require the existing facility to comply with the standards. In practice, the final determination will be made by the EPA on a case-by-case basis.

5.2.1 Examples of Potential Modifications

Examples of physical and operational changes which may increase volatile organic compound (VOC) emission rates are listed in Table 5-1 and are discussed in this section. These changes would be classified as modifications under the definition given in paragraph (a) of 40 CFR 60.14. However, because of the superceding provisions in paragraph (e), only two of the changes are classified as such. Table 5-1 indicates the effect of each change on VOC emission rate, the governing provision for that type of change, and whether or not the change is considered to be a modification.

One type of change that could increase the VOC emission rate is reformulation of the coating. This can be done either by switching from a high solids to a lower solids coating or by adding VOC to the coating. These changes would not be considered to be modifications, according to 40 CFR 60.14(e)(4). Under this provision, the use of an alternative raw material does not constitute modification if the facility was originally equipped to handle that raw material.

Another type of change that could increase the VOC emission rate is the addition of application equipment. A facility may enlarge its spray capacity by adding new spray guns in order to coat larger parts or to increase production. These additions involve capital expenditures for the facility, a situation which is not excluded by part (e)(2) of the governing provision. Since increasing the production rate by adding application equipment increases VOC emissions, this change constitutes modification.

Increasing the conveyor line speed may increase the VOC emission rate if the purpose is to meet rising production schedules. If the speed is increased to meet cleaning or rinse time specifications, the emission rate would not necessarily increase. In either case, no capital expenditure is involved, so according to Part (e)(2) the change is not modification.

Operational changes such as decreasing the conveyor speed, or increasing the number of passes through the spray booths may be

TABLE 5-1. EXAMPLES OF POTENTIAL MODIFICATIONS

Example	Effect on VOC emission rate	Subpart of 40 CFR 60.14(e)	Determination of modification
1. Switching from a high to a lower solids coating	Increase	4	No
2. Adding VOC to coating	Increase	4	No
3. Adding application equipment	Increase	2	Yes
4. Increasing conveyor speed	Possible increase	2	No
5. Increasing hours of operation	Same[a]	3	No
6. Changing part size or complexity	Possible increase	4	No
7. Switching from coating of metal parts to coating of plastic parts	Increase[b]	4	Yes[c]
8. Substituting process equipment on a temporary basis	Possible increase	1	No
9. Relocating a coating operation from another plant site	Same	6	No

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[a] Annual VOC emissions increase, although there is no effect on the hourly rate of emissions.

[b] VOC emissions increase since there are no VOC emissions from the surface coating of plastic parts when metal is being coated.

[c] This is modification if construction of the metal coating facility commenced after the proposal date of the standard. If construction commenced prior to the proposal date, then this change would not be a modification according to 40 CFR 60.14(e)4.

implemented in order to increase coating thickness. Assuming that production remains constant, these changes would result in increased hours of operation. The total annual VOC emissions would, therefore, increase while the hourly VOC emission rate would remain the same. Since the number of hours of operation would increase, these changes would be governed by subpart (e)(3) and would not be considered as modifications.

Changing part size or complexity may increase the VOC emission rate. A larger part size may increase paint consumption due to the larger surface area of the part. Coating a more complex part may also increase paint consumption, since transfer efficiency would be lower. In both cases, VOC emissions would increase, but the change would not be a modification if the facility was originally designed to accommodate the new parts.

A facility that coats metal parts may begin coating plastic parts without any changes or additional process equipment. If construction of the metal parts coating facility commenced prior to proposal of the standard, the change to begin coating plastic parts would not be a modification, according to 40 CFR 14(e)(4). A facility built after proposal of this NSPS that switched from coating metal parts to coating of plastic parts would be covered under this NSPS as a new source.

Coating application equipment may be interchanged temporarily to handle specific customer demands. Such a change may increase the VOC emission rate but would not be a modification if it was made routinely with existing equipment.

The last example given here of a potential modification is the relocation of a coating operation from one plant site to another. According to 40 CFR 60.14 (e)(6), this alone would not be considered a modification.

5.2.2 Examples of Reconstruction

According to 40 CFR 60.15(b), any equipment replacement that involves a capital expenditure of more than 50 percent of the cost of a comparable new facility is termed "reconstruction," regardless of the change in VOC emission rate. Examples of changes to existing facilities that may be considered as reconstruction are shown below:

1. Coating application equipment is replaced or enlarged.
2. Conveyor equipment is replaced or enlarged.

Under the present regulations, changes such as these are not required to be completed within a particular time. Once construction has begun, an existing facility becomes an affected facility when the expenditure exceeds 50 percent of the fixed capital cost of a comparable new facility. The enforcement division of the appropriate EPA regional office should be contacted whenever a source has questions regarding modification and reconstruction.

6. MODEL PLANTS AND REGULATORY ALTERNATIVES

This chapter describes model plants that are representative of facilities that surface coat plastic parts used in business machines. It also presents regulatory alternatives that define varying levels of volatile organic compound (VOC) emission reductions below baseline from these facilities.

6.1 MODEL PLANTS

Three model plants have been defined to include the major equipment and techniques now being used to surface coat plastic parts for business machines. The model plants are intended to reflect surface coating facilities expected to be built in the future, whether they are in-house coating operations of business machine manufacturers, large contractors who perform both molding and coating of plastic parts, or job shops performing coating services only. The three model plants represent small (Plant A), medium (Plant B), and large (Plant C) facilities.

6.1.1 Production

The model plants presented in Table 6-1 were developed on the basis of data gathered from industry and published literature. Annual coating consumption data were selected as the basis for determining the size categories because these data were more readily available than data pertaining to the total surface area coated per year. The total amount of solids sprayed is a function of coating formulation and annual coating consumption. The amount of solids applied is based on an estimated transfer efficiency of 25 percent of the total exterior coating solids and 50 percent of the EMI/RFI shielding coating solids sprayed under baseline conditions. These values are representative of transfer efficiencies reported in published literature and estimated by facilities that use air atomized spray equipment.[1-12]

TABLE 6-1. MODEL PLANT PARAMETERS[a,b]

Parameter	Plant A	Plant B	Plant C
A. Production			
1. Total volume of coating used at capacity, ℓ/yr (gal/yr)	19,409 (5,127)	155,202 (41,000)	388,030 (102,507)
2. Total solids sprayed, ℓ/yr (gal/yr)	6,420 (1,696)	51,368 (13,570)	128,424 (33,926)
3. Total solids applied, ℓ/yr (gal/yr)[c]	1,730 (457)	13,836 (3,655)	34,591 (9,138)
B. Operating Parameters			
1. Period of Operation			
a. h/d	16	16	16
b. d/wk	5	5	5
c. wk/yr	50	50	50
C. Process Parameters			
1. Type and amount of coatings used at baseline emission level			
a. Solvent-based nickel-filled acrylic for EMI/RFI shielding containing 15%, by volume, solids at the gun (17.1% of total coating consumption)			
i. Volume of coating sprayed, ℓ/yr (gal/yr)	3,331 (880)	26,498 (7,000)	66,270 (17,507)
ii. Volume of VOC sprayed, ℓ/yr (gal/yr)	2,831 (748)	22,523 (5,950)	56,329 (14,881)
iii. Volume of solids applied, ℓ/yr (gal/yr)[c]	250 (66)	1,987 (525)[d]	4,970 (1,313)[d]
b. Solvent-based two-component catalyzed urethane containing 32%, by volume, solids at the gun (53.7% of total coating consumption)			
i. Volume of coating sprayed, ℓ/yr (gal/yr)	10,410 (2,750)	83,279 (22,000)	208,198 (55,000)
ii. Volume of VOC sprayed, ℓ/yr (gal/yr)	7,079 (1,870)	56,630 (14,960)	141,574 (37,400)
iii. Volume of solids applied, ℓ/yr (gal/yr)[c]	833 (220)	6,662 (1,760)	16,656 (4,400)
c. Solvent-based two-component catalyzed urethane containing 50%, by volume, solids at the gun (19.5% of total coating consumption)			
i. Volume of coating sprayed, ℓ/yr (gal/yr)	3,785 (1,000)	30,283 (8,000)	75,708 (20,000)
ii. Volume of VOC sprayed, ℓ/yr (gal/yr)	1,893 (500)	15,142 (4,000)	37,854 (10,000)
iii. Volume of solids applied, ℓ/yr (gal/yr)[c]	473 (125)	3,785 (1,000)	9,464 (2,500)
d. Waterborne acrylic containing 37%, by volume, solids at the gun, and 12.6%, by volume, organic solvent at the gun (9.7% of total coating consumption)			
i. Volume of coating sprayed, ℓ/yr (gal/yr)	1,882 (497)	15,142 (4,000)	37,854 (10,000)
ii. Volume of VOC sprayed, ℓ/yr (gal/yr)	237 (63)	1,908 (504)	4,770 (1,260)
iii. Volume of solids applied, ℓ/yr (gal/yr)[c]	174 (46)	1,401 (370)	3,502 (925)

(continued)

TABLE 6-1. (continued)

Parameter	Plant A	Plant B	Plant C
2. Zinc consumption for zinc-arc EMI/RFI shielding			
a. Total zinc sprayed, kg/yr (lb/yr)	0	65,305 (144,101)	130,517 (288,000)
b. Zinc solids applied, kg/yr (lb/yr)	0	34,612 (76,374)	69,174 (152,640)
3. Coating equipment			
a. Conveyorized lines	0	1	2
b. Manual air atomized spray guns	2	5	9
c. Dry filter spray booths[e]	2	5 (2 batch; 3 on conveyorized line)	6 (2 batch; 4 on conveyorized line No. 1)
d. Waterwash spray booths[e]	0	0	3 (3 on conveyorized line No. 2)
e. Spray booth ventilation rate, m^3/s (acfm)	4.7 (10,000)	4.7 (10,000)	4.7 (10,000)
f. Grit blasting booths[f]	0	2	4
g. Zinc-arc spray booths[g]	0	2	4
h. Gas-fired intermediate bake ovens	0	0	1 (Conveyorized line No. 2)
i. Gas-fired final curing ovens	1	2 (1 batch oven; 1 multiple pass oven on conveyorized line)	2 (1 batch oven; 1 multiple pass oven through which both conveyor lines pass)
4. Coating application			
a. Average transfer efficiency			
i. Prime and color coats	25%	25%	25%
ii. Texture and touch-up coats	25%	25%	25%
iii. EMI/RFI nickel-filled shielding coat	50%	50%	50%
b. Average dry film thickness for EMI/RFI shielding coats			
i. Metal-filled coatings	2 mil	2 mil	2 mil
ii. Zinc-arc spray	3 mil	3 mil	3 mil
c. Average dry film thickness for exterior coats			
i. Prime/filler coat	2 mil	2 mil	2 mil
ii. Color coat	1 mil	1 mil	1 mil
iii. Texture coat	3 mil[h]	3 mil[h]	3 mil[h]
iv. Total exterior film thickness applied	6 mil	6 mil	6 mil
d. Average flash-off period			
i. EMI/RFI shielding	Variable	12 min	12 min
ii. Prime/filler coat	Variable	12 min	12 min
iii. Color coat	Variable	12 min	12 min
iv. Texture coat	Variable	12 min	12 min
e. Curing temperature and time in intermediate bake oven			
i. Prime/filler coat	N/A[i]	N/A	120°F for 10 min
ii. Color coat	N/A	N/A	120°F for 10 min
f. Curing temperature and time in final curing oven	140°F for 30 min	140°F for 30 min	140°F for 30 min
g. Average conveyor speed, m/s (ft/min)	N/A	0.04 (8)	0.04 (8)

(continued)

TABLE 6-1. (continued)

Parameter	Plant A	Plant B	Plant C
D. VOC Emissions			
1. Total solvent (VOC) emissions, Mg/yr (t/yr)	10.6 (11.7)	85 (94)	212 (234)
a. Percent VOC emissions from spray booths	80	80	80
b. Percent VOC emissions from flash-off areas	10	10	10
c. Percent VOC emissions from ovens	10	10	10

[a] The sets of values in the table were calculated by column in English units, then converted to metric units. The conversion factors used were: (a) 1 gallon (gal) equals 3.7854118 liter (ℓ); and (b) 1 Megagram (Mg) equals 1.1025 tons.

[b] Assume VOC density of 0.882 kg/ℓ (7.36 lb/gal).

[c] Assuming 25 percent transfer efficiency for exterior coats and 50 percent transfer efficiency for EMI/RFI nickel-filled shielding coats.

[d] Does not include coating solids applied by zinc arc spraying.

[e] Does not include spray booths for grit blasting stations or zinc-arc spraying stations.

[f] Includes dry filter spray booth and grit blaster.

[g] Includes waterwash spray booth and zinc-arc spray apparatus.

[h] Film thickness for texture coat cannot be measured because it is a spatter coating. The value is based on the assumption that the volume of coating used for texture is spread uniformly over the surface areas coated.

[i] N/A = Not applicable.

6.1.2 Process Parameters

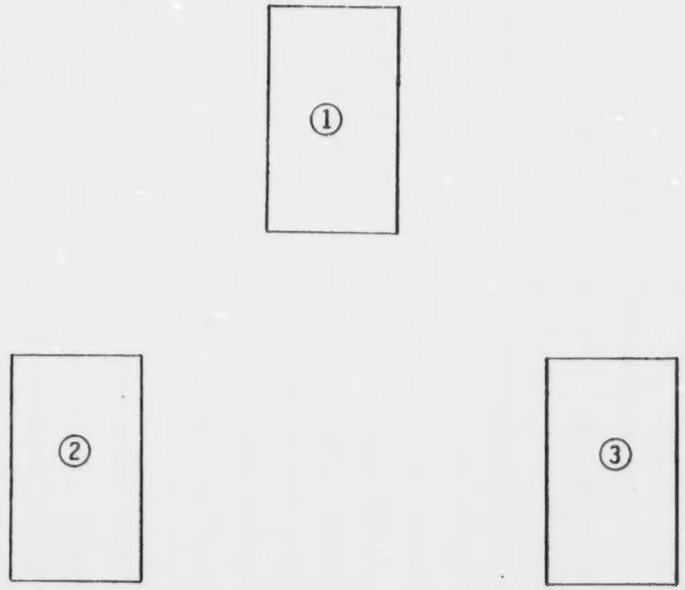
The most commonly used exterior coatings for plastic parts are organic-solvent-based two-component catalyzed urethane coatings containing about 30 percent, by volume, solids at the gun.[1,13,14] The majority of plants are also using some two-component catalyzed urethane coatings containing approximately 50 percent, by volume, solids at the gun.[1,13,14] Coatings containing greater than 60 percent, by volume, solids at the gun, have been used in production in the past, but are only being used experimentally at the present time.[15-20] Therefore, these higher solids coatings have not been included in the baseline. Two-component catalyzed urethane coatings represent approximately 90 percent of the exterior coatings consumed for plastic parts used in business machines, with the remaining 10 percent of exterior coatings being waterborne acrylic emulsions.[1,13,14]

All three model plants have the capability to perform electromagnetic interference/radio frequency interference (EMI/RFI) shielding, although not all plastic parts require it. The EMI/RFI shielding usually is accomplished by one of two methods: zinc-arc spraying, and the spray application of organic-solvent-based metal-filled coatings. Each model plant can perform shielding by the latter method, which uses conventional spray equipment, but only the two larger plants have zinc-arc spray capability, which involves the purchase of additional equipment.

Conveyorized lines also require a large capital investment that can only be recovered by facilities with high production rates. For this reason, the two larger model plants include conveyors in their coating operations. The small model plant is designed only for batch coating, in which one or more parts are manually placed in the spray booths for coating and removed from the booths to dry. Figures 6-1 through 6-3 show schematic diagrams of the three model plants.

6.1.3 VOC Emissions

Because of the lack of State regulations controlling VOC emissions from the surface coating of plastic parts, the baseline emission level was determined using coating consumption data obtained from facilities that surface coat plastic parts for business machines. Baseline emission levels for the model plants are presented in Table 6-1. These represent



LEGEND

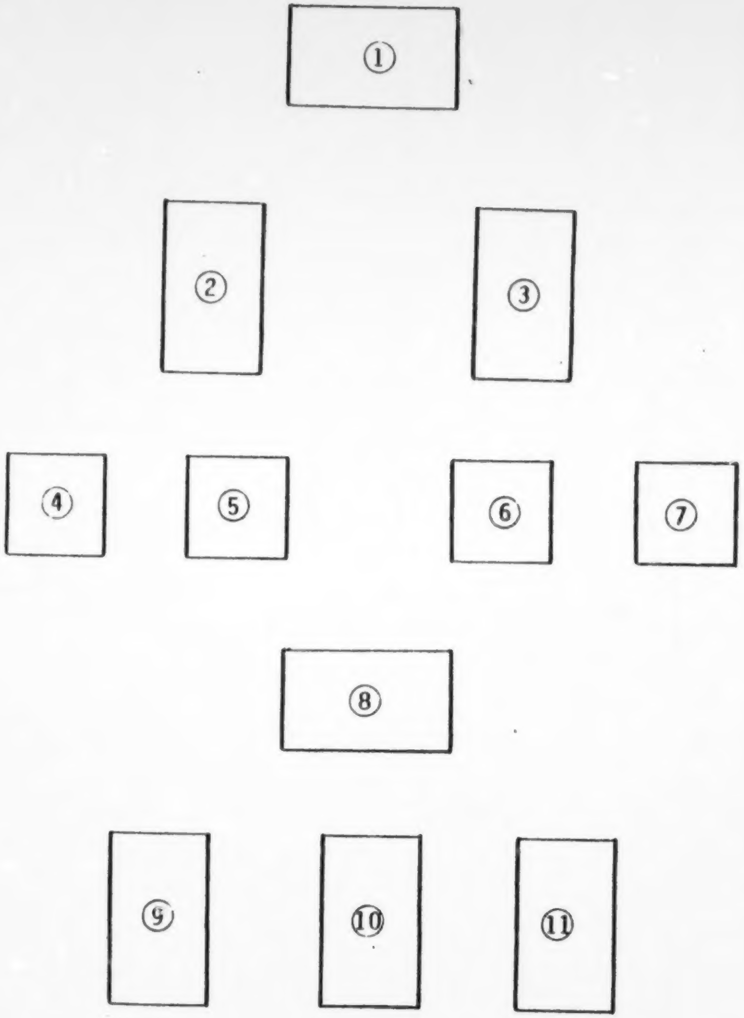
BATCH OPERATION--FOR APPLICATION OF PRIME, COLOR, TEXTURE, AND EMI/RFI SHIELDING, AS WELL AS TOUCH-UP OPERATIONS.

① FINAL CURE BAKE OVEN

② DRY FILTER SPRAY BOOTH--EQUIPPED WITH STAINLESS STEEL EQUIPMENT FOR APPLICATION OF WATERBORNE COATINGS, AS WELL AS SOLVENT-BASED COATINGS.

③ DRY FILTER SPRAY BOOTH--FOR APPLICATION OF EMI/RFI SHIELDING, AND FOR TOUCH-UP OPERATIONS.

Figure 6-1. Schematic of Model Plant A.



LEGEND

BATCH OPERATION--FOR APPLICATION OF PRIME, COLOR, OR TEXTURE COATS.

① FINAL CURE BAKE OVEN--SERVING ② AND ③.

②, ③ DRY FILTER SPRAY BOOTHS

ZINC-ARC SPRAYING--PRODUCT CAN GO TO EITHER BATCH OR CONVEYORIZED OPERATION.

④, ⑤ GRIT BLASTING STATIONS--INCLUDES DRY FILTER SPRAY BOOTH AND GRIT BLASTER.

⑥, ⑦ ZINC-ARC SPRAY BOOTHS--INCLUDES WATERWASH SPRAY BOOTH AND ZINC-ARC SPRAY APPARATUS.

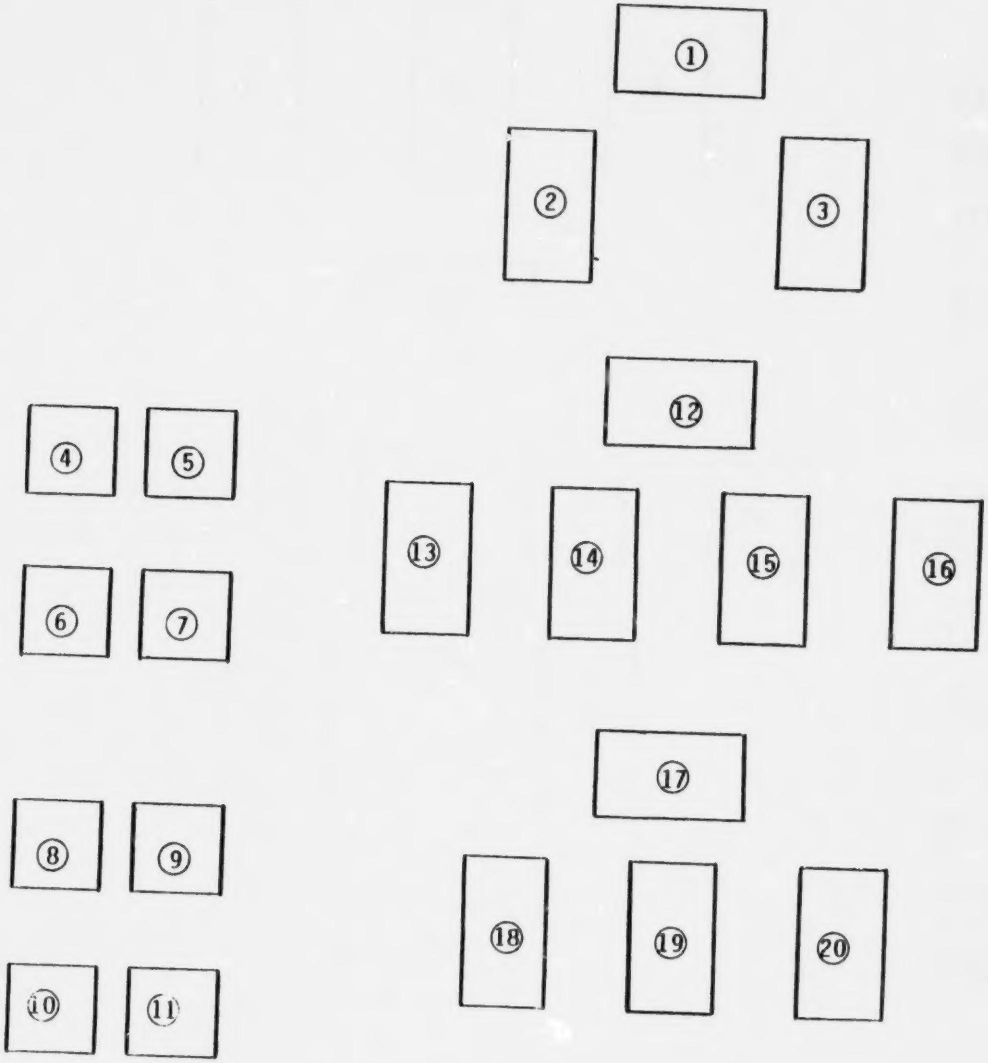
CONVEYORIZED LINE OPERATION--FOR SEQUENTIAL APPLICATION OF PRIME, COLOR, AND TEXTURE COATS.

⑧ MULTIPLE PASS FINAL CURE BAKE OVEN--SERVING ⑨, ⑩, AND ⑪.

⑨ DRY FILTER SPRAY BOOTH--EQUIPPED WITH STAINLESS STEEL EQUIPMENT FOR APPLICATION OF WATERBORNE COATINGS, AS WELL AS SOLVENT-BASED COATINGS.

⑩, ⑪ DRY FILTER SPRAY BOOTHS

Figure 6-2. Schematic of Model Plant B.



LEGEND

BATCH OPERATION

① FINAL CURE BAKE OVEN--SERVING 2 AND 3 .

②, ③ DRY FILTER SPRAY BOOTHS

ZINC-ARC SPRAYING OPERATION--PRODUCT CAN GO TO EITHER BATCH OR CONVEYORIZED OPERATION.

④, ⑤, ⑥, AND ⑦ GRIT BLASTING STATIONS--INCLUDE DRY FILTER SPRAY BOOTH AND GRIT BLASTER.

⑧, ⑨, ⑩ , AND ⑪ ZINC-ARC SPRAYING STATIONS--INCLUDES WATERWASH SPRAY BOOTH AND ZINC-ARC SPRAY APPARATUS.

CONVEYORIZED OPERATIONS--INCLUDES TWO COATINGS LINES: FOR SEQUENTIAL APPLICATION OF PRIME, COLOR, AND TEXTURE COATS.

⑫ INTERMEDIATE BAKE OVEN--SERVING SPRAY BOOTHS ⑬ , ⑭ , ⑮ , AND ⑯ .

⑬ , ⑭ , ⑮ , AND ⑯ DRY FILTER SPRAY BOOTHS (LINE 1)--BOOTH 13 IS EQUIPPED WITH STAINLESS STEEL EQUIPMENT FOR APPLICATION OF WATER-BORNE COATINGS, AS WELL AS SOLVENT-BASED COATINGS.

⑰ MULTIPLE-PASS FINAL CURE BAKE OVEN--SERVING COATING LINES 1 AND 2 .

⑱ , ⑲ , AND ⑳ WATERWASH SPRAY BOOTHS (LINE 2)

Figure 6-3. Schematic of Model Plant C.

the emission levels that would be expected if no new source performance standard (NSPS) were developed. Table 6-2 shows baseline coating utilization at a typical plant, including the VOC content of each coating used.

6.2 REGULATORY ALTERNATIVES

Thirty-two regulatory alternatives have been developed by applying the control technologies described in Chapter 4. Each alternative represents a different level of VOC emission reduction for model plants with constant levels of production. Because add-on emission control devices are not cost-effective for facilities that surface coat plastic parts for business machines, VOC emission reductions are achieved by using spray technologies that reduce coating consumption or by using coatings with lower VOC content. For example, an increased transfer efficiency results in decreased coating consumption, and a higher solids content results in a lower VOC content in the coating. Both approaches are applied to the model plants as methods of reducing VOC emissions. The regulatory alternatives are defined below, along with examples of specific control strategies that could be used to achieve them. Regulatory Alternatives II-25 through XVI-25 reflect the emission reductions that could be obtained if the model plants use lower-VOC-content coatings. Regulatory Alternatives I-25/40 through XVI-25/40 reflect the emission reductions that could be obtained by both improving the transfer efficiency for prime and color coats to 40 percent and using lower-VOC-content coatings. The alternatives are summarized in Table 6-3.

6.2.1 Alternative I-25 (Baseline)

The baseline emission level is the level of control that would exist in the absence of an NSPS. This alternative reflects the current industry practice, as shown for the model plants in Tables 6-1 and 6-2.

6.2.2 Alternative II-25

Emissions are reduced approximately 11 percent below baseline level. This reduction can be achieved by using EMI/RFI shielding coatings containing 25 percent, by volume, solids. Waterborne and organic-solvent-based exterior coatings usage remains the same as for the baseline case. A VOC emission reduction of 47 percent is obtained for the EMI/RFI

TABLE 6-2. BASELINE COATING UTILIZATION

Type of coating	Percent solids, by volume, at the gun	Percent of total coating consumption	VOC content	
			kg/ℓ of coating (lb/gal of coating), less water	kg/ℓ of solids (lb/gal of solids)
Solvent-based nickel-filled EMI/RFI shielding coating	15	17.1	0.75 (6.3)	5.00 (42.0)
Solvent-based coating No. 1	32	53.7	0.60 (5.0)	1.87 (15.6)
Solvent-based coating No. 2	50	19.5	0.44 (3.7)	0.88 (7.3)
Waterborne coating (water/VOC = 80/20)	37	9.7	0.22 (1.9)	0.30 (2.5)

TABLE 6-3. COATING UTILIZATION FOR DIFFERENT REGULATORY ALTERNATIVES

Coating material	Percent solids, by volume, at the gun	Percent of total coating solids applied for each regulatory alternative[a]															
		I-25	II-25	III-25	IV-25	V-25	VI-25	VII-25	VIII-25	IX-25	X-25	XI-25	XII-25	XIII-25	XIV-25	XV-25	XVI-25
1. Lower solids solvent borne exterior coatings	32	48	48	48	48	0	0	0	0	0	0	0	0	0	0	0	0
2. Medium solids solvent borne exterior coatings	50	27	27	27	27	75	75	75	0	75	0	0	0	0	0	0	0
3. Higher solids solvent borne exterior coatings	60	0	0	0	0	0	0	0	75	0	75	75	0	75	0	0	0
4. Waterborne exterior coatings (water/VOC = 80/20)	37	10	10	10	10	10	10	10	10	10	10	10	85	10	85	85	85
5. Lower solids solvent borne EMI/RFI shielding coatings	15	15	0	0	0	15	0	0	15	0	0	0	15	0	0	0	0
6. Higher solids solvent borne EMI/RFI shielding coatings	25	0	15	0	0	0	15	0	0	0	15	0	0	0	15	0	0
7. Waterborne EMI/RFI shielding coatings (water/VOC = 72/28)	33	0	0	15	0	0	0	15	0	0	0	15	0	0	0	15	0
8. Zinc-arc spray shielding[b]	100	0	0	0	15	0	0	0	0	15	0	0	0	15	0	0	15
Emission reduction below baseline, wt %	--	0	11	21	23	31	42	52	46	55	57	67	60	69	71	81	83

[a] For Regulatory Alternatives I-25 through XVI-25, coatings are applied with air atomized spray guns at 25 percent transfer efficiency for all exterior coats and at 50 percent transfer efficiency for EMI/RFI shielding coats. For Regulatory Alternatives I-25/40 through XVI-25/40, prime and color are applied with air-assisted airless or electrostatic spray guns at 40 percent transfer efficiency. Texture and touch-up coats are applied with air-atomized spray at 25 percent transfer efficiency.

[b] The values given do not include the shielding applied by zinc-arc spray stations existing in baseline model plants.

TABLE 6-3. (continued)

Coating material	Percent of total coating solids applied for each regulatory alternative[a]															
	I-25/40	II-25/40	III-25/40	IV-25/40	V-25/40	VI-25/40	VII-25/40	VIII-25/40	IX-25/40	X-25/40	XI-25/40	XII-25/40	XIII-25/40	XIV-25/40	XV-25/40	XVI-25/40
1. Lower solids solvent borne exterior coatings	48	48	48	48	0	0	0	0	0	0	0	0	0	0	0	0
2. Medium solids solvent borne exterior coatings	27	27	27	27	75	75	75	0	75	0	0	0	0	0	0	0
3. Higher solids solvent borne exterior coatings	0	0	0	0	0	0	0	75	0	75	75	0	75	0	0	0
4. Waterborne exterior coatings (water/VOC = 80/20)	10	10	10	10	10	10	10	10	10	10	10	85	10	85	85	85
5. Lower solids solvent borne EMI/RFI shielding coatings	15	0	0	0	15	0	0	15	0	0	0	15	0	0	0	0
6. Higher solids solvent borne EMI/RFI shielding coatings	0	15	0	0	0	15	0	0	0	15	0	0	0	15	0	0
7. Waterborne EMI/RFI shielding coatings (water/VOC = 72/28)	0	0	15	0	0	0	15	0	0	0	15	0	0	0	15	0
8. Zinc-arc spray shielding[b]	0	0	0	15	0	0	0	0	15	0	0	0	15	0	0	15
Emission reduction below baseline, wt %	14	25	35	38	40	51	61	51	63	62	72	63	75	74	84	86

shielding process, but emissions from the exterior coating process are unchanged.

6.2.3 Alternative III-25

Emissions are reduced approximately 21 percent below baseline level. This reduction can be achieved by using waterborne EMI/RFI shielding coatings. Waterborne and organic-solvent-based exterior coatings usage remains the same as for the baseline case. A VOC emission reduction of 89 percent is obtained for the EMI/RFI shielding process, but emissions from the exterior coating process are unchanged.

6.2.4 Alternative IV-25

Emissions are reduced approximately 23 percent below baseline level. This reduction can be achieved by using non-VOC-emitting EMI/RFI shielding methods. Waterborne and organic-solvent-based exterior coatings usage remains the same as for the baseline case. A VOC emission reduction of 100 percent is obtained for the EMI/RFI shielding process, but emissions from the exterior coating process are unchanged.

6.2.5 Alternative V-25

Emissions are reduced approximately 31 percent below baseline level. This reduction can be achieved by using organic-solvent-based exterior coatings containing 50 percent, by volume, solids. Waterborne exterior coatings usage and EMI/RFI coatings usage remain the same as for the baseline case. A VOC emission reduction of 41 percent is obtained for the exterior coating process, but emissions from the EMI/RFI shielding process are unchanged.

6.2.6 Alternative VI-25

Emissions are reduced approximately 42 percent below baseline level. This reduction can be achieved by using organic-solvent-based exterior coatings containing 50 percent, by volume, solids and by using organic-solvent-based EMI/RFI shielding coatings containing 25 percent, by volume, solids. Usage of waterborne exterior coatings remains the same as for the baseline case. The VOC emission reductions obtained for the EMI/RFI shielding process and the exterior coating process are 47 percent and 41 percent, respectively.

6.2.7 Alternative VII-25

Emissions are reduced approximately 52 percent below baseline level. This reduction can be achieved by using organic-solvent-based exterior coatings containing 50 percent, by volume, solids and by using waterborne EMI/RFI shielding coatings. Usage of waterborne exterior coatings remains the same as for the baseline case. The VOC emission reductions obtained for the EMI/RFI shielding process and the exterior coating process are 89 percent and 41 percent, respectively.

6.2.8 Alternative VIII-25

Emissions are reduced approximately 46 percent below baseline level. This reduction can be achieved by using organic-solvent-based exterior coatings containing 60 percent, by volume, solids. Waterborne exterior coatings usage and EMI/RFI coatings usage remain the same as for the baseline case. A VOC emission reduction of 60 percent is obtained for the exterior coating process, but emissions from the EMI/RFI shielding process are unchanged.

6.2.9 Alternative IX-25

Emissions are reduced approximately 55 percent below baseline level. This reduction can be achieved by using organic-solvent-based exterior coatings containing 50 percent, by volume, solids and by using non-VOC-emitting EMI/RFI shielding methods. Usage of waterborne exterior coatings remains the same as for the baseline case. The VOC emission reductions obtained for the EMI/RFI shielding process and the exterior coating process are 100 percent and 41 percent, respectively.

6.2.10 Alternative X-25

Emissions are reduced approximately 57 percent below baseline level. This reduction can be achieved by using organic-solvent-based exterior coatings containing 60 percent, by volume, solids and by using organic-solvent-based EMI/RFI shielding coatings containing 25 percent, by volume, solids. Usage of waterborne exterior coatings remains the same as for the baseline case. The VOC emission reductions obtained for the EMI/RFI shielding process and the exterior coating process are 47 percent and 60 percent, respectively.

6.2.11 Alternative XI-25

Emissions are reduced approximately 67 percent below baseline level. This reduction can be achieved by using organic-solvent-based exterior coatings containing 60 percent, by volume, solids and by using waterborne EMI/RFI shielding coatings. Usage of waterborne exterior coatings remains the same as for the baseline case. The VOC emission reductions obtained for the EMI/RFI shielding process and the exterior coating process are 89 percent and 60 percent, respectively.

6.2.12 Alternative XII-25

Emissions are reduced approximately 60 percent below baseline level. This reduction can be achieved by using waterborne exterior coatings. Usage of EMI/RFI coatings remains the same as for the baseline case. A VOC emission reduction of 78 percent is obtained for the exterior coating process, but emissions from the EMI/RFI shielding process are unchanged.

6.2.13 Alternative XIII-25

Emissions are reduced approximately 69 percent below baseline level. This reduction can be achieved by using organic-solvent-based exterior coatings containing 60 percent, by volume, solids and by using non-VOC-emitting EMI/RFI shielding methods. Usage of waterborne exterior coatings remains the same as for the baseline case. The VOC emission reductions obtained for the EMI/RFI shielding process and the exterior coating process are 100 percent and 60 percent, respectively.

6.2.14 Alternative XIV-25

Emissions are reduced approximately 71 percent below baseline level. This reduction can be achieved by using waterborne exterior coatings and by using organic-solvent-based EMI/RFI shielding coatings containing 25 percent, by volume, solids. The VOC emission reductions obtained for the EMI/RFI shielding process and the exterior coating process are 47 percent and 78 percent, respectively.

6.2.15 Alternative XV-25

Emissions are reduced approximately 81 percent below baseline level. This reduction can be achieved by using waterborne exterior coatings and by using waterborne EMI/RFI shielding coatings. The VOC emission reductions obtained for the EMI/RFI shielding process and the exterior coating process are 89 percent and 78 percent, respectively.

6.2.16 Alternative XVI-25

Emissions are reduced approximately 83 percent below baseline level. This reduction can be achieved by using waterborne exterior coatings and by using non-VOC-emitting EMI/RFI shielding methods. The VOC emission reductions obtained for the EMI/RFI shielding process and the exterior coating process are 100 percent and 78 percent, respectively.

6.2.17 Alternatives I-25/40 through XVI-25/40

For Regulatory Alternatives I-25/40 through XVI-25/40, emissions from exterior coating processes are reduced approximately 14 percent below the levels expected for Regulatory Alternatives I-25 through XVI-25. This reduction corresponds to an increase in transfer efficiency from 25 percent to 40 percent for prime and color coats, obtained by using air-assisted airless or electrostatic air spray equipment. Table 6-4 illustrates the emission reduction potential of each regulatory alternative as a function of transfer efficiency.

TABLE 6-4. EMISSION REDUCTION POTENTIAL OF REGULATORY ALTERNATIVES AS A FUNCTION OF TRANSFER EFFICIENCY

VOC emission reduction, wt %	25[a]	25/40[b]
0-10	I	
11-15	II	I
16-20		
21-25	III, IV	II
26-30		
31-35	V	III
36-40		IV, V
41-45	VI	
46-50	VIII	
51-55	VII, IX	VI, VIII
56-60	X, XII	
61-65		VII, IX, X, XII
66-70	XI, XIII	
71-75	XIV	XI, XIII, XIV
76-80		
81-85	XV, XVI	XV
86-90		XVI
91-95		
96-100		

[a] 25 percent transfer efficiency (TE) for exterior coating, 50 percent TE for metal-filled EMI/RFI shielding coating.

[b] 40 percent TE for prime and color exterior coating, 25 percent for texture and touch-up exterior coating, and 50 percent TE for metal-filled EMI/RFI shielding coating.

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7. ENVIRONMENTAL IMPACT

This chapter presents a discussion of the environmental impact of each of the regulatory alternatives that were presented in Chapter 6. The discussion includes the impact of each regulatory alternative on air, water and solid waste emissions, and on energy consumption. All calculations and conclusions regarding environmental impact are based on the model plants described in Chapter 6 and on the industry growth projections presented in Chapter 8.

7.1 AIR POLLUTION IMPACT

The air pollution impact of each regulatory alternative is presented in Section 7.1.1 in terms of volatile organic compound (VOC) emissions. Consideration is given to other air emissions occurring during the coating process in Section 7.1.2.

7.1.1 VOC Emissions

The contribution of specific coatings to the total VOC emissions from each of the model plants discussed in Chapter 6 is shown in Tables 7-1, 7-2, and 7-3. Table 7-4 summarizes the total VOC emissions from model plants A, B, and C for each regulatory alternative.

Nationwide VOC emissions from facilities that surface coat plastic business machine parts and that will be subject to the new source performance standard (NSPS) have also been estimated for each regulatory alternative. Because statistical data on the coating process are sparse, a number of assumptions were made to estimate both present and future VOC emissions. The supporting data and underlying assumptions used to estimate nationwide emissions are discussed in the following sections.

7.1.1.1 Nationwide Emissions from Exterior Coating in 1985 and 1990. The VOC emissions from exterior coating of plastic parts for business machines were estimated by the following steps:

1. The mass of plastic consumed for business machines was calculated using a 17 percent average annual growth rate from a baseline of 31.8 $\times 10^6$ kilograms (70 $\times 10^6$ lb) of plastic consumed for business machines in 1980.[1-3] A 50:50 split by weight was assumed between parts molded as structural foam (SF) and straight-injection-molded (SIM) plastic. (See Tables 7-5 and 7-6.)

2. The mass of SF and SIM plastic coated was calculated by assuming that 90 percent of SF parts and 10 percent of SIM parts receive exterior coatings.

3. The mass of SF and SIM plastic coated by plants covered by the NSPS versus plants not covered by the NSPS was calculated by assuming that one-third of the growth in surface coated plastic parts between 1985 and 1990 would be absorbed by plants not covered by the NSPS. Plants not covered by the NSPS would include plastic parts coating facilities built before proposal of the NSPS and metal parts coating facilities built before proposal of the NSPS that switch to the coating of plastic parts.

4. The surface areas of SF and SIM parts coated were calculated by assuming an average density and thickness for each type of part. An average SF part density of 1 g/cm^3 (62.4 lb/ft^3) and an average wall thickness of 0.635 cm (0.25 in.) were assumed to calculate the surface area of SF coated. An average SIM part density of 1.1 g/cm^3 (68.6 lb/ft^3) and an average wall thickness of 0.318 cm (0.125 in.) were assumed to calculate the surface area of SIM plastic coated. Estimates of surface areas receiving exterior coating are presented in Tables 7-5 and 7-6.

5. The volume of coating solids applied to each type of part was calculated by assuming an average exterior coating thickness of 6 mils for SF parts and 0.5 mils for SIM parts and multiplying the film thickness by the surface area coated.

6. The volume of exterior coating sprayed and the VOC emissions occurring due to the spraying were calculated for each type of part by applying the baseline coating utilization data to the volume of coating

solids applied (calculated in Step 5) and by assuming an average transfer efficiency of 25 percent. Baseline exterior coating utilization for SF parts is a mix of organic-solvent-based and waterborne coatings that was described in Chapters 3 and 6. A "worst case" VOC emission number was generated for coating SIM parts by assuming a fog coating baseline for all SIM parts. This baseline assumes that SIM parts receive 0.5 mils of coating solids and are coated with an organic-solvent-based coating containing 15 percent, by volume, solids.

As a result of these calculations, it was found that VOC emissions from the exterior coating of SIM parts (~550 Mg/yr [600 tons/yr]) will account for only about 6 percent of the total VOC emissions from exterior coating of plastic parts for business machines in 1990. The main reason for this is because more SF parts than SIM parts are coated. Furthermore, SF parts are coated with a greater film thickness than SIM parts. Because VOC emissions from exterior coating of SIM parts account for such a small fraction of the total, the VOC emissions from exterior coating of SF parts alone were used to estimate nationwide VOC emissions in Table 7-7 and to estimate the total number of plants.

The total volume of exterior coating consumed was combined with the model plant parameters in Table 6-1 to derive the number of plants performing coating.[3] The 1985 exterior coating consumption was assumed to be split equally between small and medium plants (Model Plants A and B, respectively). At the present time, no large plants are known to be consuming 388,030 liters (ℓ) (102,507 gallons) per year, so Model Plant C was excluded from the calculations for 1985.

-1985 exterior coating consumption = 8.14×10^6 ℓ/yr (2.15×10^6 gal/yr).
-Number of small plants = 253
-Number of medium plants = 32
-Number of large plants = 0

Values for nationwide emissions from exterior coating of SF (presented in Table 7-7) were calculated by multiplying the number of plants by the VOC emissions presented in Table 7-4.

The procedure used above was also used to project the number of facilities in 1990. The number of existing facilities from 1985 was held constant, and it was assumed that existing facilities (i.e., facilities not covered by the NSPS) absorbed one-third of the growth between 1985 and 1990. It was assumed that one new large facility will be constructed between 1985 and 1990, and that the remaining volume of coating not sprayed by the large plant is divided evenly between the new medium and small plants. The total number of plants and exterior coating consumption derived by this procedure are as follows:

- 1990 total exterior coating consumption = 17.9 x10^6 ℓ/yr (4.72 x10^6 gal/yr.)
- Total number of small plants = 444
- Total number of medium plants = 56
- Total number of large plants = 1

Values for nationwide emissions from exterior coating in 1985 and 1990 are presented in Table 7-7. These estimates are based on a baseline exterior coating consumption rate of 8.14 x10^6 ℓ/yr (2.15 x10^6 gal/yr) by existing facilities in 1985, and consumption rates of 11.4 x10^6 ℓ/yr (3.01 x10^6 gal/yr) for existing facilities and 6.47 x10^6 ℓ/yr (1.71 x10^6 gal/yr) for new facilities in 1990. The VOC emission estimate for 1990 assumes that existing facilities will increase their production to absorb one-third of the growth in exterior coating of plastic parts between 1985 and 1990.

7.1.1.2 Nationwide Emissions from EMI/RFI Shielding Coating in 1985 and 1990. Both SF and SIM parts are coated for EMI/RFI shielding at the same types of facilities which are characterized by the three sizes of model plants. Therefore, it was assumed that the estimated number of existing and new facilities presented in the previous section could be combined with the EMI/RFI coating consumption at each type of plant to derive a VOC emission estimate for EMI/RFI shielding of plastic parts for business machines. Emissions estimates for EMI/RFI shielding processes appear in Table 7-7. These estimates are based on a baseline EMI/RFI shielding coating consumption rate of 1.69 x10^6 ℓ/yr (0.446 x10^6 gal/yr) by existing facilities in 1985, and consumption rates of 2.37 x10^6 ℓ/yr (0.626 x10^6 gal/yr) for existing facilities and 1.34 x10^6 ℓ/yr (0.354 x10^6 gal/yr) for new facilities in 1990. The VOC emission estimate for 1990 assumes that existing facilities increase their production to absorb one-third of the growth in EMI/RFI shielding of plastic parts.

7.1.2 Other Emissions

Other air emissions that might be affected by the various regulatory alternatives include nickel particles emitted from spraying of nickel-filled EMI/RFI shielding coatings, aluminum oxide particles from grit blasting prior to zinc-arc spraying, and zinc oxide fumes from zinc-arc spraying operations. Dry filters and water walls in spray booths often have particulate removal efficiencies in excess of 99 percent; therefore, the air impacts of the regulatory alternatives on emissions of nickel particles, aluminum oxide particles, zinc particles, and zinc oxide fumes are expected to be minor.

7.2 WATER POLLUTION IMPACT

Processes in plastic parts surface coating facilities that use water are waterwash spray booths and dip tanks for electroless plating. Waterwash spray booths are equipped with a water curtain that removes overspray particles from the spray booth exhaust. Water pollution results from the dissolution of soluble overspray components into the water. Most of the insoluble material is collected as sludge, but some of this material is dispersed in the water. The types of water pollutants likely to result from spray coating operations include organic solvents, resins, pigments such as lead chromates and titanium dioxide, nickel particles from EMI/RFI shielding coatings, and zinc from zinc-arc spraying.

Water pollution from coating facilities employing electroless plating tanks for EMI/RFI shielding results from dragout. Dragout is defined as the volume of solution carried over the edge of a process tank by an emerging piece of work. This solution usually ends up in the water used to clean the application area, or in process drains. Examples of water pollutants emitted from plating processes are sulfuric acid and nickel and chromium compounds.

Only the State of Wisconsin has specific regulations for the electroplating industry. The Wisconsin Administrative Code, Chapter NR 260, establishes effluent limitations, standards of performance, and pretreatment standards for discharge by electroplaters. Federal water pollution regulations for this and other industries are governed by the Water Pollution Control Act. This Act specifies several levels of control:

1. For existing plants, best practical control technology currently available (BPCTCA/BPT) by 1977.

2. For existing plants, best available technology economically achievable (BATEA/BAT) by 1983.

3. For new sources, new source performance standards (NSPS) considering costs and any nonwater quality environmental impact and energy requirements. The Act allows States to establish more stringent control levels than Federal standards if desired.

Methods currently employed by the coating industry to handle wastewater and sludge include discharging to a sanitary sewer, recycling, incineration, and hauling to a licensed disposal site.

Methods that facilities can employ to reduce water pollution include: improving transfer efficiencies, the use of dry filter spray booths, and in-plant controls. Air-assisted airless and electrostatic spray methods reduce overspray and, thus, can decrease the volume of wastewater from waterwash spray booths. Use of dry filter spray booths instead of waterwash spray booths will reduce the amount of wastewater but increase the amount of solid waste generated by a plant. Examples of in-plant controls include separation of process and nonprocess water and reusing and recyling water.

7.3 SOLID WASTE DISPOSAL IMPACT

The majority of solid waste generated by the surface coating process is produced by coating overspray collected by dry filter and waterwash spray booths. Solid waste is usually in the form of dirty filters from dry filter spray booths and sludge from waterwash spray booths. Methods that are commonly used to dispose of solid wastes include hauling to a licensed disposal site and incineration. Dried coating solids can be treated as nonhazardous wastes and disposed of in landfills.

Solid waste impacts of the regulatory alternatives are outlined in Table 7-8 for each of the model plants. It is evident from this table that Regulatory Alternatives I-25/40 through XVI-25/40 reduce the volume of solid waste generated by the model plants by 25 percent. These regulatory alternatives represent improved average transfer efficiency for prime and color exterior coating; therefore, the solid waste created by overspray is reduced. Regulatory alternatives that only use zinc-arc spray for EMI/RFI shielding also reduce solid waste production. This reduction is based on the assumption that zinc overspray will be recovered and sold by coaters.

Solid waste generated by the model plants can be extrapolated to estimate the nationwide solid waste disposal impact of the regulatory alternatives. Regulatory alternatives that call for 40-percent transfer efficiency for prime and color exterior coating provide a nationwide solid waste emission reduction of 11 percent from facilities that surface coat plastic parts for business machines.

7.4 ENERGY IMPACT

Because coatings for plastic business machine parts must cure at a low temperature to avoid damaging the plastic, the energy consumption for this process is lower than for similar metal coating processes. Many of the organic-solvent-based coatings used on plastic business machine parts can be cured at room temperature. Most organic-solvent-based coating manufacturers recommend a baking schedule to achieve optimum finish quality. Waterborne coatings generally require a low temperature oven cure. However, most coaters use low temperature ovens to speed up production regardless of the types of coatings used. Some coaters feel that increased oven air flows, and even intermediate baking between coats, are necessary to produce an acceptable finish with waterborne coatings.[4] Regulatory alternatives that require the exclusive use of waterborne exterior coatings or waterborne EMI/RFI shielding coatings might increase energy consumption at some surface coating plants, due to the use of higher air flow rates or longer curing times. However, waterborne coatings are cured at temperatures which are in the range of 50° to 60°C (125° to 140°F) similar to those used for organic-solvent-based coatings. Therefore, the energy impact of the regulatory alternatives specifying waterborne coatings is expected to be negligible.

7.5 OTHER ENVIRONMENTAL IMPACTS

Some of the regulatory alternatives may have impacts on the health and safety of workers at surface coating plants. Worker exposure to some of the materials used in the surface coating process must be controlled through the use of respirators and proper ventilation. The use of some of these substances could be affected by the regulatory alternatives. Examples of hazardous materials that might be affected by the regulatory alternatives are listed in Table 7-9.

Regulatory alternatives that specify the use of waterborne coatings could reduce worker exposure to organic solvents and isocyanates. Fire hazards could also be reduced by use of waterborne coatings.

Regulatory alternatives that specify non-VOC-emitting EMI/RFI shielding methods could reduce worker exposure to organic solvents and nickel particles present in nickel-filled EMI/RFI shielding coatings; however, other occupational hazards are associated with non-VOC-emitting EMI/RFI shielding methods. Zinc-arc spray operators must be protected from zinc oxide fumes and noise. Electroless plating techniques employ acids and soluble nickel and chromium compounds that are toxic. The EMI/RFI shielding options presented in the regulatory alternatives have different types of health risks associated with them, so none of them can be singled out as having the greatest impact on worker safety and health.

7.6 OTHER ENVIRONMENTAL CONCERNS

7.6.1 Irreversible and Irretrievable Commitment of Resources

For many of the regulatory alternatives, additional equipment will be required. Manufacturing such equipment will consume steel and other raw materials. However, consumption of resources for this purpose will be small compared to the national usage of each resource.

TABLE 7-1. ANNUAL VOC EMISSIONS FROM MODEL PLANT A FOR EACH REGULATORY ALTERNATIVE

Coating type	Percent solvent, by volume	VOC emissions, Mg/yr (tons/yr)															
		I-25	II-25	III-25	IV-25[a]	V-25	VI-25	VII-25	VIII-25	IX-25[a]	X-25	XI-25	XII-25	XIII-25[a]	XIV-25	XV-25	XVI-25[a]
Lower solids exterior	68	6.24 (6.88)	6.24 (6.88)	6.24 (6.88)	6.24 (6.88)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Medium solids exterior	50	1.67 (1.84)	1.67 (1.84)	1.67 (1.84)	1.67 (1.84)	4.61 (5.08)	4.61 (5.08)	4.61 (5.08)	0.00 (0.00)	4.61 (5.08)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Higher solids exterior	40	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	3.07 (3.39)	0.00 (0.00)	3.07 (3.39)	3.07 (3.39)	0.00 (0.00)	3.07 (3.39)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Waterborne exterior	12.6	0.21 (0.23)	0.21 (0.23)	0.21 (0.23)	0.21 (0.23)	0.21 (0.23)	0.21 (0.23)	0.21 (0.23)	0.21 (0.23)	0.21 (0.23)	0.21 (0.23)	0.21 (0.23)	1.78 (1.96)	0.21 (0.23)	1.78 (1.96)	1.78 (1.96)	1.78 (1.96)
Total exterior coatings		8.12 (8.95)	8.12 (8.95)	8.12 (8.95)	8.12 (8.95)	4.82 (5.31)	4.82 (5.31)	4.82 (5.31)	3.28 (3.62)	4.82 (5.31)	3.28 (3.62)	3.28 (3.62)	1.78 (1.96)	3.28 (3.62)	1.78 (1.96)	1.78 (1.96)	1.78 (1.96)
Lower solids EMI/RFI	85	2.48 (2.74)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	2.48 (2.74)	0.00 (0.00)	0.00 (0.00)	2.48 (2.74)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	2.48 (2.74)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Medium solids EMI/RFI	75	0.00 (0.00)	1.31 (1.45)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.31 (1.45)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.31 (1.45)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.31 (1.45)	0.00 (0.00)	0.00 (0.00)
Waterborne EMI/RFI	20	0.00 (0.00)	0.00 (0.00)	0.27 (0.29)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.27 (0.29)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.27 (0.29)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.27 (0.29)	0.00 (0.00)
Total EMI/RFI coatings		2.48 (2.74)	1.31 (1.45)	0.27 (0.29)	0.00 (0.00)	2.48 (2.74)	1.31 (1.45)	0.27 (0.29)	2.48 (2.74)	0.00 (0.00)	1.31 (1.45)	0.27 (0.29)	2.48 (2.74)	0.00 (0.00)	1.31 (1.45)	0.27 (0.29)	0.00 (0.00)
Total emissions		10.61 (11.69)	9.44 (10.40)	8.39 (9.25)	8.12 (8.95)	7.30 (8.05)	6.13 (6.76)	5.08 (5.60)	5.76 (6.35)	4.82 (5.31)	4.60 (5.07)	3.55 (3.91)	4.26 (4.70)	3.28 (3.62)	3.09 (3.41)	2.04 (2.25)	1.78 (1.96)

TABLE 7-1. (continued)

Coating type	VOC emissions, Mg/yr (tons/yr)															
	I-25/40	II-25/40	III-25/40	IV-25/40[a]	V-25/40	VI-25/40	VII-25/40	VIII-25/40	IX-25/40[a]	X-25/40	XI-25/40	XII-25/40	XIII-25/40[a]	XIV-25/40	XV-25/40	XVI-25/40[a]
Lower solids exterior	5.07 (5.59)	5.07 (5.59)	5.07 (5.59)	5.07 (5.59)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Medium solids exterior	1.36 (1.49)	1.36 (1.49)	1.36 (1.49)	1.36 (1.49)	3.74 (4.13)	3.74 (4.13)	3.74 (4.13)	0.00 (0.00)	3.74 (4.13)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Higher solids exterior	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	2.50 (2.75)	0.00 (0.00)	2.50 (2.75)	2.50 (2.75)	0.00 (0.00)	2.50 (2.75)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Waterbone exterior	0.17 (0.19)	0.17 (0.19)	0.17 (0.19)	0.17 (0.19)	0.17 (0.19)	0.17 (0.19)	0.17 (0.19)	0.17 (0.19)	0.17 (0.19)	0.17 (0.19)	0.17 (0.19)	1.45 (1.59)	0.17 (0.19)	1.45 (1.59)	1.45 (1.59)	1.45 (1.59)
Total exterior coatings	6.60 (7.27)	6.60 (7.27)	6.60 (7.27)	6.60 (7.27)	3.91 (4.31)	3.91 (4.31)	3.91 (4.31)	2.67 (2.94)	3.91 (4.31)	2.67 (2.94)	2.67 (2.94)	1.45 (1.59)	2.67 (2.94)	1.45 (1.59)	1.45 (1.59)	1.45 (1.59)
Lower solids EMI/RFI	2.48 (2.74)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	2.48 (2.74)	0.00 (0.00)	0.00 (0.00)	2.48 (2.74)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	2.48 (2.74)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Medium solids EMI/RFI	0.00 (0.00)	1.31 (1.45)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.31 (1.45)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.31 (1.45)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	1.31 (1.45)	0.00 (0.00)	0.00 (0.00)
Waterbone EMI/RFI	0.00 (0.00)	0.00 (0.00)	0.27 (0.29)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.27 (0.29)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.27 (0.29)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.27 (0.29)	0.00 (0.00)
Total EMI/RFI coatings	2.48 (2.74)	1.31 (1.45)	0.27 (0.29)	0.00 (0.00)	2.48 (2.74)	1.31 (1.45)	0.27 (0.29)	2.48 (2.74)	0.00 (0.00)	1.31 (1.45)	0.27 (0.29)	2.48 (2.74)	0.00 (0.00)	1.31 (1.45)	0.27 (0.29)	0.00 (0.00)
Total emissions	9.08 (10.01)	7.91 (8.72)	6.86 (7.57)	6.60 (7.27)	6.40 (7.05)	5.23 (5.76)	4.18 (4.61)	5.15 (5.68)	3.91 (4.31)	3.98 (4.39)	2.93 (3.23)	3.93 (4.33)	2.67 (2.94)	2.76 (3.04)	1.71 (1.89)	1.45 (1.59)

[a] Shielding is performed by a non-VOC-emitting process.

TABLE 7-2. ANNUAL VOC EMISSIONS FROM MODEL PLANT B FOR EACH REGULATORY ALTERNATIVE

Coating type	Percent solvent, by volume	VOC emissions, Mg/yr (tons/yr)															
		I-25	II-25	III-25	IV-25[a]	V-25	VI-25	VII-25	VIII-25	IX-25[a]	X-25	XI-25	XII-25	XIII-25[a]	XIV-25	XV-25	XVI-25[a]
Lower solids exterior	68	49.95 (55.05)	49.95 (55.05)	49.95 (55.05)	49.95 (55.05)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Medium solids exterior	50	13.36 (14.72)	13.36 (14.72)	13.36 (14.72)	13.36 (14.72)	36.85 (40.63)	36.85 (40.63)	36.85 (40.63)	0.00 (0.00)	36.85 (40.63)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Higher solids exterior	40	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	24.57 (27.08)	0.00 (0.00)	24.57 (27.08)	24.57 (27.08)	0.00 (0.00)	24.57 (27.08)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Waterborne exterior	12.6	1.68 (1.85)	1.68 (1.85)	1.68 (1.85)	1.68 (1.85)	1.68 (1.85)	1.68 (1.85)	1.68 (1.85)	1.68 (1.85)	1.68 (1.85)	1.68 (1.85)	1.68 (1.85)	14.23 (15.69)	1.68 (1.85)	14.23 (15.69)	14.23 (15.69)	14.23 (15.69)
Total exterior coatings		64.98 (71.63)	64.98 (71.63)	64.98 (71.63)	64.98 (71.63)	38.54 (42.48)	38.54 (42.48)	38.54 (42.48)	26.25 (28.94)	38.54 (42.48)	26.25 (28.94)	26.25 (28.94)	14.23 (15.69)	26.25 (28.94)	14.23 (15.69)	14.23 (15.69)	14.23 (15.69)
Lower solids EMI/RFI	85	19.86 (21.90)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	19.86 (21.90)	0.00 (0.00)	0.00 (0.00)	19.86 (21.90)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	19.86 (21.90)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Medium solids EMI/RFI	75	0.00 (0.00)	10.52 (11.59)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	10.52 (11.59)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	10.52 (11.59)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	10.52 (11.59)	0.00 (0.00)	0.00 (0.00)
Waterborne EMI/RFI	20	0.00 (0.00)	0.00 (0.00)	2.12 (2.34)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	2.12 (2.34)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	2.12 (2.34)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	2.12 (2.34)	0.00 (0.00)
Total EMI/RFI coatings		19.86 (21.90)	10.52 (11.59)	2.12 (2.34)	0.00 (0.00)	19.86 (21.90)	10.52 (11.59)	2.12 (2.34)	19.86 (21.90)	0.00 (0.00)	10.52 (11.59)	2.12 (2.34)	19.86 (21.90)	0.00 (0.00)	10.52 (11.59)	2.12 (2.34)	0.00 (0.00)
Total emissions		84.85 (93.53)	75.50 (83.22)	67.11 (73.97)	64.98 (71.63)	58.40 (64.38)	49.05 (54.07)	40.66 (44.82)	46.12 (50.83)	38.54 (42.48)	36.77 (40.53)	28.38 (31.28)	34.10 (37.58)	26.25 (28.94)	24.75 (27.28)	16.36 (18.03)	14.23 (15.69)

TABLE 7-2. (continued)

Coating type	VOC emissions, Mg/yr (tons/yr)															
	I-25/40	II-25/40	III-25/40	IV-25/40[a]	V-25/40	VI-25/40	VII-25/40	VIII-25/40	IX-25/40[a]	X-25/40	XI-25/40	XII-25/40	XIII-25/40[a]	XIV-25/40	XV-25/40	XVI-25/40[a]
Lower solids exterior	40.58 (44.73)	40.58 (44.73)	40.58 (44.73)	40.58 (44.73)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Medium solids exterior	10.85 (11.96)	10.85 (11.96)	10.85 (11.96)	10.85 (11.96)	29.94 (33.01)	29.94 (33.01)	29.94 (33.01)	0.00 (0.00)	29.94 (33.01)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Higher solids exterior	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	19.96 (22.01)	0.00 (0.00)	19.96 (22.01)	19.96 (22.01)	0.00 (0.00)	19.96 (22.01)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Waterbone exterior	1.37 (1.51)	1.37 (1.51)	1.37 (1.51)	1.37 (1.51)	1.37 (1.51)	1.37 (1.51)	1.37 (1.51)	1.37 (1.51)	1.37 (1.51)	1.37 (1.51)	1.37 (1.51)	11.56 (12.75)	1.37 (1.51)	11.56 (12.75)	11.56 (12.75)	11.56 (12.75)
Total exterior coatings	52.80 (58.20)	52.80 (58.20)	52.80 (58.20)	52.80 (58.20)	31.31 (34.51)	31.31 (34.51)	31.31 (34.51)	21.33 (23.51)	31.31 (34.51)	21.33 (23.51)	21.33 (23.51)	11.56 (12.75)	21.33 (23.51)	11.56 (12.75)	11.56 (12.75)	11.56 (12.75)
Lower solids EMI/RFI	19.86 (21.90)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	19.86 (21.90)	0.00 (0.00)	0.00 (0.00)	19.86 (21.90)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	19.86 (21.90)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Medium solids EMI/RFI	0.00 (0.00)	10.52 (11.59)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	10.52 (11.59)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	10.52 (11.59)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	10.52 (11.59)	0.00 (0.00)	0.00 (0.00)
Waterbone EMI/RFI	0.00 (0.00)	0.00 (0.00)	2.12 (2.34)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	2.12 (2.34)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	2.12 (2.34)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	2.12 (2.34)	0.00 (0.00)
Total EMI/RFI coatings	19.86 (21.90)	10.52 (11.59)	2.12 (2.34)	0.00 (0.00)	19.86 (21.90)	10.52 (11.59)	2.12 (2.34)	19.86 (21.90)	0.00 (0.00)	10.52 (11.59)	2.12 (2.34)	19.86 (21.90)	0.00 (0.00)	10.52 (11.59)	2.12 (2.34)	0.00 (0.00)
Total emissions	72.66 (80.10)	63.32 (69.79)	54.92 (60.54)	52.80 (58.20)	51.18 (56.41)	41.83 (46.11)	33.44 (36.86)	41.19 (45.41)	31.31 (34.51)	31.85 (35.10)	23.45 (25.85)	31.43 (34.64)	21.33 (23.51)	22.08 (24.34)	13.69 (15.09)	11.56 (12.75)

[a] Shielding is performed by a non-VOC-emitting process.

TABLE 7-3. ANNUAL VOC EMISSIONS FROM MODEL PLANT C FOR EACH REGULATORY ALTERNATIVE

Coating type	Percent solvent, by volume	VOC emissions, Mg/yr (tons/yr)															
		I-25	II-25	III-25	IV-25[a]	V-25	VI-25	VII-25	VIII-25	IX-25[a]	X-25	XI-25	XII-25	XIII-25[a]	XIV-25	XV-25	XVI-25[a]
Lower solids exterior	68	124.81 (137.58)	124.81 (137.58)	124.81 (137.58)	124.81 (137.58)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Medium solids exterior	50	33.38 (36.80)	33.38 (36.80)	33.38 (36.80)	33.38 (36.80)	92.12 (101.54)	92.12 (101.54)	92.12 (101.54)	0.00 (0.00)	92.12 (101.54)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Higher solids exterior	40	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	61.41 (67.70)	0.00 (0.00)	61.41 (67.70)	61.41 (67.70)	0.00 (0.00)	61.41 (67.70)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Waterborne exterior	12.6	4.21 (4.64)	4.21 (4.64)	4.21 (4.64)	4.21 (4.64)	4.21 (4.64)	4.21 (4.64)	4.21 (4.64)	4.21 (4.64)	4.21 (4.64)	4.21 (4.64)	4.21 (4.64)	35.58 (39.22)	4.21 (4.64)	35.58 (39.22)	35.58 (39.22)	35.58 (39.22)
Total exterior coatings		162.40 (179.02)	162.40 (179.02)	162.40 (179.02)	162.40 (179.02)	96.33 (106.18)	96.33 (106.18)	96.33 (106.18)	65.62 (72.33)	96.33 (106.18)	65.62 (72.33)	65.62 (72.33)	35.58 (39.22)	65.62 (72.33)	35.58 (39.22)	35.58 (39.22)	35.58 (39.22)
Lower solids EMI/RFI	85	49.67 (54.75)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	49.67 (54.75)	0.00 (0.00)	0.00 (0.00)	49.67 (54.75)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	49.67 (54.75)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Medium solids EMI/RFI	75	0.00 (0.00)	26.30 (28.99)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	26.30 (28.99)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	26.30 (28.99)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	26.30 (28.99)	0.00 (0.00)	0.00 (0.00)
Waterborne EMI/RFI	20	0.00 (0.00)	0.00 (0.00)	5.31 (5.86)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	5.31 (5.86)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	5.31 (5.86)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	5.31 (5.86)	0.00 (0.00)
Total EMI/RFI coatings		49.67 (54.75)	26.30 (28.99)	5.31 (5.86)	0.00 (0.00)	49.67 (54.75)	26.30 (28.99)	5.31 (5.86)	49.67 (54.75)	0.00 (0.00)	26.30 (28.99)	5.31 (5.86)	49.67 (54.75)	0.00 (0.00)	26.30 (28.99)	5.31 (5.86)	0.00 (0.00)
Total emissions		212.07 (233.77)	188.70 (208.00)	167.72 (184.87)	162.40 (179.02)	146.00 (160.93)	122.62 (135.17)	101.64 (112.04)	115.29 (127.08)	96.33 (106.18)	91.92 (101.32)	70.93 (78.19)	85.25 (93.97)	65.62 (72.33)	61.87 (68.20)	40.89 (45.07)	35.58 (39.22)

[a] Shielding is performed by a non-VOC-emitting process.

TABLE 7-3. (continued)

Coating type	VOC emissions, Mg/yr (tons/yr)															
	I-25/40	II-25/40	III-25/40	IV-25/40[a]	V-25/40	VI-25/40	VII-25/40	VIII-25/40	IX-25/40[a]	X-25/40	XI-25/40	XII-25/40	XIII-25/40[a]	XIV-25/40	XV-25/40	XVI-25/40[a]
Lower solids exterior	101.41 (111.79)	101.41 (111.79)	101.41 (111.79)	101.41 (111.79)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Medium solids exterior	27.12 (29.90)	27.12 (29.90)	27.12 (29.90)	27.12 (29.90)	74.85 (82.50)	74.85 (82.50)	74.85 (82.50)	0.00 (0.00)	74.85 (82.50)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Higher solids exterior	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	49.90 (55.00)	0.00 (0.00)	49.90 (55.00)	49.90 (55.00)	0.00 (0.00)	49.90 (55.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Waterbone exterior	3.42 (3.77)	3.42 (3.77)	3.42 (3.77)	3.42 (3.77)	3.42 (3.77)	3.42 (3.77)	3.42 (3.77)	3.42 (3.77)	3.42 (3.77)	3.42 (3.77)	3.42 (3.77)	28.91 (31.86)	3.42 (3.77)	28.91 (31.86)	28.91 (31.86)	28.91 (31.86)
Total exterior coatings	131.95 (145.45)	131.95 (145.45)	131.95 (145.45)	131.95 (145.45)	78.26 (86.27)	78.26 (86.27)	78.26 (86.27)	53.32 (58.77)	78.26 (86.27)	53.32 (58.77)	53.32 (58.77)	28.91 (31.86)	53.32 (58.77)	28.91 (31.86)	28.91 (31.86)	28.91 (31.86)
Lower solids EMI/RFI	49.67 (54.75)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	49.67 (54.75)	0.00 (0.00)	0.00 (0.00)	49.67 (54.75)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	49.67 (54.75)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)
Medium solids EMI/RFI	0.00 (0.00)	26.30 (28.99)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	26.30 (28.99)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	26.30 (28.99)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	26.30 (28.99)	0.00 (0.00)	0.00 (0.00)
Waterbone EMI/RFI	0.00 (0.00)	0.00 (0.00)	5.31 (5.86)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	5.31 (5.86)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	5.31 (5.86)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	5.31 (5.86)	0.00 (0.00)
Total EMI/RFI coatings	49.67 (54.75)	26.30 (28.99)	5.31 (5.86)	0.00 (0.00)	49.67 (54.75)	26.30 (28.99)	5.31 (5.86)	49.67 (54.75)	0.00 (0.00)	26.30 (28.99)	5.31 (5.86)	49.67 (54.75)	0.00 (0.00)	26.30 (28.99)	5.31 (5.86)	0.00 (0.00)
Total emissions	181.62 (200.20)	158.25 (174.44)	137.27 (151.31)	131.95 (145.45)	127.94 (141.02)	104.56 (115.26)	83.58 (92.13)	102.99 (113.52)	78.26 (86.27)	79.61 (87.76)	58.63 (64.63)	78.58 (86.62)	53.32 (58.77)	55.20 (60.85)	34.22 (37.72)	28.91 (31.86)

[a] Shielding is performed by a non-VOC-emitting process.

TABLE 7-4. SUMMARY OF ANNUAL VOC EMISSIONS FROM MODEL PLANTS, A, B, AND C FOR EACH REGULATORY ALTERNATIVE

	VOC emissions, Mg/yr (ton/yr)								
	Model Plant A			Model Plant B			Model Plant C		
Reg. Alt.	EMI/RFI coating emissions	Exterior coating emissions	Total emissions	EMI/RFI coating emissions	Exterior coating emissions	Total emissions	EMI/RFI coating emissions	Exterior coating emissions	Total emissions
I-25	2.48 (2.74)	8.12 (8.95)	10.61 (11.69)	19.86 (21.90)	64.98 (71.63)	84.85 (93.53)	49.67 (54.75)	162.40 (179.02)	212.07 (233.77)
II-25	1.31 (1.45)	8.12 (8.95)	9.44 (10.40)	10.52 (11.59)	64.98 (71.63)	75.50 (83.22)	26.30 (28.99)	162.40 (179.02)	188.70 (208.00)
III-25	0.27 (0.29)	8.12 (8.95)	8.39 (9.25)	2.12 (2.34)	64.98 (71.63)	67.11 (73.97)	5.31 (5.86)	162.40 (179.02)	167.72 (184.87)
IV-25	0.00 (0.00)	8.12 (8.95)	8.12 (8.95)	0.00 (0.00)	64.98 (71.63)	64.98 (71.63)	0.00 (0.00)	162.40 (179.02)	162.40 (179.02)
V-25	2.48 (2.74)	4.82 (5.31)	7.30 (8.05)	19.86 (21.90)	38.54 (42.49)	58.41 (64.38)	49.67 (54.75)	96.33 (106.18)	146.00 (160.93)
VI-25	1.31 (1.45)	4.82 (5.31)	6.13 (6.76)	10.52 (11.59)	38.54 (42.49)	49.06 (54.08)	26.30 (28.99)	96.33 (106.18)	122.63 (135.17)
VII-25	0.27 (0.29)	4.82 (5.31)	5.08 (5.60)	2.12 (2.34)	38.54 (42.49)	40.67 (44.83)	5.31 (5.86)	96.33 (106.18)	101.64 (112.04)
VIII-25	2.48 (2.74)	3.28 (3.62)	5.76 (6.35)	19.86 (21.90)	26.26 (28.94)	46.12 (50.84)	49.67 (54.75)	65.62 (72.33)	115.29 (127.08)
IX-25	0.00 (0.00)	4.82 (5.31)	4.82 (5.31)	0.00 (0.00)	38.54 (42.49)	38.54 (42.49)	0.00 (0.00)	96.33 (106.18)	96.33 (106.18)
X-25	1.31 (1.45)	3.28 (3.62)	4.60 (5.07)	10.52 (11.59)	26.26 (28.94)	36.77 (40.53)	26.30 (28.99)	65.62 (72.33)	91.92 (101.32)
XI-25	0.27 (0.29)	3.28 (3.62)	3.55 (3.91)	2.12 (2.34)	26.26 (28.94)	28.38 (31.28)	5.31 (5.86)	65.62 (72.33)	70.93 (78.19)
XII-25	2.48 (2.74)	1.78 (1.96)	4.26 (4.70)	19.86 (21.90)	14.23 (15.69)	34.10 (37.59)	49.67 (54.75)	35.58 (39.22)	85.25 (93.97)
XIII-25	0.00 (0.00)	3.28 (3.62)	3.28 (3.62)	0.00 (0.00)	26.26 (28.94)	26.26 (28.94)	0.00 (0.00)	65.62 (72.33)	65.62 (72.33)
XIV-25	1.31 (1.45)	1.78 (1.96)	3.09 (3.41)	10.52 (11.59)	14.23 (15.69)	24.75 (27.28)	26.30 (28.99)	35.58 (39.22)	61.87 (68.20)
XV-25	0.27 (0.29)	1.78 (1.96)	2.04 (2.25)	2.12 (2.34)	14.23 (15.69)	16.36 (18.03)	5.31 (5.86)	35.58 (39.22)	40.89 (45.07)
XVI-25	0.00 (0.00)	1.78 (1.96)	1.78 (1.96)	0.00 (0.00)	14.23 (15.69)	14.23 (15.69)	0.00 (0.00)	35.58 (39.22)	35.58 (39.22)
I-25/40	2.48 (2.74)	6.60 (7.27)	9.08 (10.01)	19.86 (21.90)	52.80 (58.20)	72.66 (80.10)	49.67 (54.75)	131.95 (145.45)	181.62 (200.20)
II-25/40	1.31 (1.45)	6.60 (7.27)	7.91 (8.72)	10.52 (11.59)	52.80 (58.20)	63.32 (69.79)	26.30 (28.99)	131.95 (145.45)	158.25 (174.44)
III-25/40	0.27 (0.29)	6.60 (7.27)	6.86 (7.57)	2.12 (2.34)	52.80 (58.20)	54.92 (60.54)	5.31 (5.86)	131.95 (145.45)	137.27 (151.31)
IV-25/40	0.00 (0.00)	6.60 (7.27)	6.60 (7.27)	0.00 (0.00)	52.80 (58.20)	52.80 (58.20)	0.00 (0.00)	131.95 (145.45)	131.95 (145.45)

(continued)

TABLE 7-4. (continued)

	VOC emissions, Mg/yr (ton/yr)								
	Model Plant A			Model Plant B			Model Plant C		
Reg. Alt.	EMI/RFI coating emissions	Exterior coating emissions	Total emissions	EMI/RFI coating emissions	Exterior coating emissions	Total emissions	EMI/RFI coating emissions	Exterior coating emissions	Total emissions
V-25/40	2.48 (2.74)	3.91 (4.31)	6.40 (7.05)	19.86 (21.90)	31.32 (34.52)	51.18 (56.41)	49.67 (54.75)	78.26 (86.27)	127.94 (141.02)
VI-25/40	1.31 (1.45)	3.91 (4.31)	5.23 (5.76)	10.52 (11.59)	31.32 (34.52)	41.83 (46.11)	26.30 (28.99)	78.26 (86.27)	104.56 (115.26)
VII-25/40	0.27 (0.29)	3.91 (4.31)	4.18 (4.61)	2.12 (2.34)	31.32 (34.52)	33.44 (36.86)	5.31 (5.86)	78.26 (86.27)	83.58 (92.13)
VIII-25/40	2.48 (2.74)	2.67 (2.94)	5.15 (5.68)	19.86 (21.90)	21.33 (23.52)	41.20 (45.41)	49.67 (54.75)	53.32 (58.77)	102.99 (113.52)
IX-25/40	0.00 (0.00)	3.91 (4.31)	3.91 (4.31)	0.00 (0.00)	31.32 (34.52)	31.32 (34.52)	0.00 (0.00)	78.26 (86.27)	78.26 (86.27)
X-25/40	1.31 (1.45)	2.67 (2.94)	3.98 (4.39)	10.52 (11.59)	21.33 (23.52)	31.85 (35.11)	26.30 (28.99)	53.32 (58.77)	79.61 (87.76)
XI-25/40	0.27 (0.29)	2.67 (2.94)	2.93 (3.23)	2.12 (2.34)	21.33 (23.52)	23.46 (25.86)	5.31 (5.86)	53.32 (58.77)	58.63 (64.63)
XII-25/40	2.48 (2.74)	1.45 (1.59)	3.93 (4.33)	19.86 (21.90)	11.57 (12.75)	31.43 (34.64)	49.67 (54.75)	28.91 (31.86)	78.58 (86.62)
XIII-25/40	0.00 (0.00)	2.67 (2.94)	2.67 (2.94)	0.00 (0.00)	21.33 (23.52)	21.33 (23.52)	0.00 (0.00)	53.32 (58.77)	53.32 (58.77)
XIV-25/40	1.31 (1.45)	1.45 (1.59)	2.76 (3.04)	10.52 (11.59)	11.57 (12.75)	22.08 (24.34)	26.30 (28.99)	28.91 (31.86)	55.20 (60.85)
XV-25/40	0.27 (0.29)	1.45 (1.59)	1.71 (1.89)	2.12 (2.34)	11.57 (12.75)	13.69 (15.09)	5.31 (5.86)	28.91 (31.86)	34.22 (37.72)
XVI-25/40	0.00 (0.00)	1.45 (1.59)	1.45 (1.59)	0.00 (0.00)	11.57 (12.75)	11.57 (12.75)	0.00 (0.00)	28.91 (31.86)	28.91 (31.86)

[a] Shielding is performed by a non-VOC-emitting process.

TABLE 7-5. PROJECTED CONSUMPTION OF STRUCTURAL FOAM (SF) FOR BUSINESS MACHINE PARTS[a]

Year	Total plastic consumed,[b] 10^6 kg (10^6 lb)	SF consumed,[c] 10^6 kg (10^6 lb)	SF coated, 10^6 kg (10^6 lb)			SF coated, 10^6 m^2 (10^6 ft^2)		
			Total[d]	By existing facilities[e]	By NSPS-regulated facilities	Total[f]	By existing facilitities	By NSPS-regulated facilities
1980	31.8 (70.0)	15.9 (35.0)	14.3 (31.5)	14.3 (31.5)	--	2.25 (24.2)	2.25 (24.2)	--
1981	37.1 (81.9)	18.6 (41.0)	16.7 (36.9)	16.7 (36.9)	--	2.64 (28.4)	2.64 (28.4)	--
1982	43.5 (95.8)	21.7 (47.9)	19.6 (43.1)	19.6 (43.1)	--	3.07 (33.1)	3.07 (33.1)	--
1983	50.8 (112)	25.4 (56.0)	22.9 (50.4)	22.9 (50.4)	--	3.60 (38.8)	3.60 (38.8)	--
1984	59.4 (131)	29.7 (65.5)	26.8 (59.0)	26.8 (59.0)	--	4.22 (45.4)	4.22 (45.4)	--
1985[g]	69.4 (153)	34.7 (76.5)	31.3 (68.9)	31.3 (68.9)	--	4.92 (53.0)	4.92 (53.0)	--
1986	81.6 (180)	40.8 (90.0)	36.7 (81.0)	33.1 (72.9)	3.7 (8.1)	5.79 (62.3)	5.21 (56.1)	0.58 (6.2)
1987	95.3 (210)	47.6 (105)	42.9 (94.5)	35.1 (77.4)	7.7 (17.1)	6.75 (72.7)	5.53 (59.5)	1.23 (13.2)
1988	112 (246)	55.8 (123)	50.3 (111)	37.6 (82.9)	12.7 (28.1)	7.93 (85.4)	5.93 (63.8)	2.01 (21.6)
1989	131 (288)	65.3 (144)	59.0 (130)	40.5 (89.3)	18.5 (40.7)	9.29 (100)	6.38 (68.7)	2.91 (31.3)
1990	152 (336)	76.2 (168)	68.5 (151)	43.7 (96.3)	24.8 (54.7)	10.8 (116)	6.88 (74.1)	3.91 (42.1)

[a] The sets of values in the table were calculated by column in English units, then converted to metric units. Tabulated values were usually rounded to three significant places, but exact values were used for conversion to metric units. The conversion factors used were: (a) 1 kilogram (kg) equals 2.2046 pounds (lb); and (b) 1 square meter (m^2) equals 10.76 square feet (ft^2).

[b] Plastic consumed for business machines was calculated using a 17 percent average annual growth rate from a baseline of 70 x10^6 lb of plastic consumed for business machines in 1980 (see references 1 and 2).

[c] Assumes a 50:50 split by weight between plastic molded as SF and straight-injection-molded (SIM) plastic (see reference 2).

[d] Assumes 90 percent of SF parts receive exterior coating.

[e] Assumes that one-third of the growth in coated business machine parts can be absorbed by excess capacity of existing plastic parts coating facilities and by metal parts coating facilities that switch over to the coating of plastic parts.

[f] Square footage coated is calculated using the pounds of SF coated from columns 4-6 and assuming an average SF density of 1.00 g/cm³ (62.42 lb/ft³) and an average wall thickness of 0.25 in (0.02083 ft). The formula used to calculate square footage is:

$$\text{Sq ft coated} = \frac{(\text{lb SF coated})}{(62.42\ \text{lb/ft}^3)(0.02083\ \text{ft})}$$

[g] Assumes NSPS proposal in late 1985.

TABLE 7-6. PROJECTED CONSUMPTION OF STRAIGHT-INJECTION-MOLDED (SIM) PLASTIC FOR BUSINESS MACHINE PARTS[a]

Year	Total plastic consumed,[b] 10^6 kg (10^6 lb)	SIM consumed,[c] 10^6 kg (10^6 lb)	SIM coated, 10^6 kg (10^6 lb)			SIM coated, 10^6 m² (10^6 ft²)		
			Total[d]	By existing facilities[e]	By NSPS-regulated facilities	Total[f]	By existing facilitities	By NSPS-regulated facilities
1980	31.8 (70.0)	15.9 (35.0)	1.59 (3.50)	1.59 (3.50)	--	0.45 (4.89)	0.45 (4.89)	--
1981	37.1 (81.9)	18.6 (41.0)	1.86 (4.10)	1.86 (4.10)	--	0.53 (5.73)	0.53 (5.73)	--
1982	43.5 (95.8)	21.7 (47.9)	2.17 (4.79)	2.17 (4.79)	--	0.62 (6.69)	0.62 (6.69)	--
1983	50.8 (112)	25.4 (56.0)	2.54 (5.60)	2.54 (5.60)	--	0.73 (7.83)	0.73 (7.83)	--
1984	59.4 (131)	29.7 (65.5)	2.97 (6.55)	2.97 (6.55)	--	0.85 (9.15)	0.85 (9.15)	--
1985[g]	69.4 (153)	34.7 (76.5)	3.47 (7.65)	3.47 (7.65)	--	0.99 (10.7)	0.99 (10.7)	--
1986	81.6 (180)	40.8 (90.0)	4.08 (9.00)	3.67 (8.10)	0.41 (0.90)	1.17 (12.6)	1.05 (11.3)	0.12 (1.26)
1987	95.3 (210)	47.6 (105)	4.76 (10.5)	3.90 (8.60)	0.86 (1.90)	1.36 (14.7)	1.11 (1.20)	0.25 (2.66)
1988	112 (246)	55.8 (123)	5.58 (12.3)	4.18 (9.23)	1.40 (3.08)	1.60 (17.2)	1.19 (12.8)	0.41 (4.35)
1989	131 (288)	65.3 (144)	6.53 (14.4)	4.48 (9.89)	2.05 (4.51)	1.87 (20.1)	1.28 (13.8)	0.59 (6.30)
1990	152 (336)	76.2 (168)	7.62 (16.8)	4.86 (10.7)	2.76 (6.10)	2.18 (23.5)	1.39 (15.0)	0.79 (8.53)

[a] The sets of values in the table were calculated by column in English units, then converted to metric units. Tabulated values were usually rounded to three significant places, but exact values were used for conversion to metric units. The conversion factors used were: (a) 1 kilogram (kg) equals 2.2046 pounds (lb); and (b) 1 square meter (m²) equals 10.76 square feet (ft²).

[b] Plastic consumed for business machines was calculated using a 17 percent average annual growth rate from a baseline of 70 x10^6 lb of plastic consumed for business machines in 1980 (see references 1 and 2).

[c] Assumes a 50:50 split by weight between plastic molded as SF and straight-injection-molded (SIM) plastic (see reference 2).

[d] Assumes 10 percent of SIM parts receive exterior coating.

[e] Assumes that one-third of the growth in coated business machine parts can be absorbed by excess capacity of existing plastic parts coating facilities and by metal parts coating facilities that switch over to the coating of plastic parts.

[f] Square footage coated is calculated using the pounds of SIM coated from columns 4-6 and assuming an average SIM density of 1.1 g/cm³ (68.66 lb/ft³) and an average wall thickness of 0.125 in (0.01042 ft). The formula used to calculate square footage is:

$$\text{Sq ft coated} = \frac{(\text{lb SIM coated})}{(68.66\ \text{lb/ft}^3)(0.01042\ \text{ft})}$$

[g] Assumes NSPS proposal in late 1985.

TABLE 7-7. TOTAL NATIONWIDE EMISSIONS FROM THE COATING OF PLASTIC PARTS FOR BUSINESS MACHINES
Mg/yr[a] (tons/yr)

	1985 Emissions			Total 1990 emissons			Emissions in 1990 NSPS affected facilities		
Reg. Alt.	EMI/RFI coating emissions	Exterior coating emissions	Total emissions	EMI/RFI coating emissions	Exterior coating emissions	Total emissions	EMI/RFI coating emissions	Exterior coating emissions	Total emissions
I-25	1,264 (1,393)	4,134 (4,557)	5,398 (5,951)	2,772 (3,055)	9,067 (9,995)	11,839 (13,050)	1,001 (1,103)	3,273 (3,608)	4,274 (4,711)
II-25	-- (--)	-- (--)	-- (--)	2,301 (2,536)	9,067 (9,995)	11,368 (12,531)	530 (584)	3,273 (3,608)	3,803 (4,192)
III-25	-- (--)	-- (--)	-- (--)	1,878 (2,070)	9,067 (9,995)	10,945 (12,065)	107 (118)	3,273 (3,608)	3,380 (3,726)
IV-25	-- (--)	-- (--)	-- (--)	1,771 (1,952)	9,067 (9,995)	10,838 (11,947)	0 (0)	3,273 (3,608)	3,273 (3,608)
V-25	-- (--)	-- (--)	-- (--)	2,772 (3,055)	7,735 (8,526)	10,507 (11,582)	1,001 (1,103)	1,941 (2,140)	2,942 (3,243)
VI-25	-- (--)	-- (--)	-- (--)	2,324 (2,562)	7,735 (8,526)	10,059 (11,088)	553 (610)	1,941 (2,140)	2,495 (2,750)
VII-25	-- (--)	-- (--)	-- (--)	1,878 (2,070)	7,735 (8,526)	9,613 (10,597)	107 (118)	1,941 (2,140)	2,048 (2,258)
VIII-25	-- (--)	-- (--)	-- (--)	2,772 (3,055)	7,116 (7,844)	9,888 (10,899)	1,001 (1,103)	1,323 (1,458)	2,323 (2,561)
IX-25	-- (--)	-- (--)	-- (--)	1,771 (1,952)	7,735 (8,526)	9,506 (10,479)	0 (0)	1,941 (2,140)	1,941 (2,140)
X-25	-- (--)	-- (--)	-- (--)	2,301 (2,536)	7,116 (7,844)	9,417 (10,380)	530 (584)	1,323 (1,458)	1,852 (2,042)
XI-25	-- (--)	-- (--)	-- (--)	1,878 (2,070)	7,116 (7,844)	8,994 (9,914)	107 (118)	1,323 (1,458)	1,430 (1,576)
XII-25	-- (--)	-- (--)	-- (--)	2,772 (3,055)	6,511 (7,177)	9,282 (10,232)	1,001 (1,103)	717 (790)	1,718 (1,893)
XIII-25	-- (--)	-- (--)	-- (--)	1,771 (1,952)	7,116 (7,844)	8,887 (9,796)	0 (0)	1,323 (1,458)	1,323 (1,458)
XIV-25	-- (--)	-- (--)	-- (--)	2,301 (2,536)	6,511 (7,177)	8,811 (9,713)	530 (584)	717 (790)	1,247 (1,374)
XV-25	-- (--)	-- (--)	-- (--)	1,878 (2,070)	6,511 (7,177)	8,389 (9,247)	107 (118)	717 (790)	824 (908)
XVI-25	-- (--)	-- (--)	-- (--)	1,771 (1,952)	6,511 (7,177)	8,282 (9,129)	0 (0)	717 (790)	717 (790)
I-25/40	-- (--)	-- (--)	-- (--)	2,772 (3,055)	8,453 (9,318)	11,225 (12,373)	1,001 (1,103)	2,660 (2,932)	3,660 (4,035)
II-25/40	-- (--)	-- (--)	-- (--)	2,301 (2,536)	8,453 (9,318)	10,754 (11,854)	530 (584)	2,660 (2,932)	3,189 (3,516)
III-25/40	-- (--)	-- (--)	-- (--)	1,878 (2,070)	8,453 (9,318)	10,331 (11,388)	107 (118)	2,660 (2,932)	2,767 (3,050)
IV-25/40	-- (--)	-- (--)	-- (--)	1,771 (1,952)	8,453 (9,318)	10,224 (11,270)	0 (0)	2,660 (2,932)	2,660 (2,932)

(continued)

TABLE 7-7. (continued)

	1985 Emissions			Total 1990 emissons			Emissions in 1990 NSPS affected facilities		
Reg. Alt.	EMI/RFI coating emissions	Exterior coating emissions	Total emissions	EMI/RFI coating emissions	Exterior coating emissions	Total emissions	EMI/RFI coating emissions	Exterior coating emissions	Total emissions
V-25/40	-- (--)	-- (--)	-- (--)	2,772 (3,055)	7,371 (8,125)	10,143 (11,180)	1,001 (1,103)	1,577 (1,739)	2,578 (2,842)
VI-25/40	-- (--)	-- (--)	-- (--)	2,324 (2,562)	7,371 (8,125)	9,695 (10,687)	553 (610)	1,577 (1,739)	2,131 (2,348)
VII-25/40	-- (--)	-- (--)	-- (--)	1,878 (2,070)	7,371 (8,125)	9,249 (10,195)	107 (118)	1,577 (1,739)	1,684 (1,857)
VIII-25/40	-- (--)	-- (--)	-- (--)	2,772 (3,055)	6,868 (7,571)	9,640 (10,626)	1,001 (1,103)	1,075 (1,184)	2,075 (2,288)
IX-25/40	-- (--)	-- (--)	-- (--)	1,771 (1,952)	7,371 (8,125)	9,142 (10,077)	0 (0)	1,577 (1,739)	1,577 (1,739)
X-25/40	-- (--)	-- (--)	-- (--)	2,301 (2,536)	6,868 (7,571)	9,169 (10,107)	530 (584)	1,075 (1,184)	1,604 (1,768)
XI-25/40	-- (--)	-- (--)	-- (--)	1,878 (2,070)	6,868 (7,571)	8,746 (9,641)	107 (118)	1,075 (1,184)	1,182 (1,302)
XII-25/40	-- (--)	-- (--)	-- (--)	2,772 (3,055)	6,376 (7,029)	9,148 (10,084)	1,001 (1,103)	583 (642)	1,583 (1,745)
XIII-25/40	-- (--)	-- (--)	-- (--)	1,771 (1,952)	6,868 (7,571)	8,639 (9,523)	0 (0)	1,075 (1,184)	1,075 (1,184)
XIV-25/40	-- (--)	-- (--)	-- (--)	2,301 (2,536)	6,376 (7,029)	8,677 (9,565)	530 (584)	583 (642)	1,112 (1,226)
XV-25/40	-- (--)	-- (--)	-- (--)	1,878 (2,070)	6,376 (7,029)	8,254 (9,099)	107 (118)	583 (642)	690 (760)
XVI-25/40	-- (--)	-- (--)	-- (--)	1,771 (1,952)	6,376 (7,029)	8,147 (8,981)	0 (0)	583 (642)	583 (642)

[a] All values were calculated in metric units and converted into English units using the conversion factor 1 megagram (Mg) equals 1.1023 tons.

TABLE 7-8. ANNUAL SOLID WASTES GENERATED AS A RESULT OF OVERSPRAY FROM THE COATING OF PLASTIC PARTS FOR BUSINESS MACHINES

Source of solid waste[b]	Solid waste generated, ℓ/yr (gal/yr)[a]							
	-25 alternatives				-25/40 alternatives			
	Reg. Alt. employing VOC emitting EMI/RFI shielding[c]		Reg. Alt. employing non-VOC emitting EMI/RFI shielding[d]		Reg. Alt. employing VOC emitting EMI/RFI shielding[e]		Reg. Alt. employing non-VOC emitting EMI/RFI shielding[f]	
Model Plant A								
EMI/RFI shielding	248	(66)	0	(0)	248	(66)	0	(0)
Exterior coating	4,443	(1,174)	4,443	(1,174)	3,335	(881)	3,335	(881)
Spray booth filters	78,658	(20,779)	78,658	(20,779)	58,993	(15,584)	58,993	(15,584)
Total solid waste	83,349	(22,018)	83,100	(21,953)	62,577	(16,531)	62,328	(16,465)
Model Plant B								
EMI/RFI shielding	1,987	(525)	0	(0)	1,987	(525)	0	(0)
Exterior coating	35,544	(9,390)	35,544	(9,390)	26,685	(7,049)	26,685	(7,049)
Spray booth filters	196,645	(51,948)	157,316	(41,558)	147,484	(38,961)	117,987	(31,169)
Total solid waste	234,176	(61,863)	192,860	(50,948)	176,156	(46,535)	144,672	(38,218)
Model Plant C								
EMI/RFI shielding	4,969	(1,313)	0	(0)	4,969	(1,313)	0	(0)
Exterior coating	88,836	(23,468)	88,836	(23,468)	66,853	(17,661)	66,853	(17,661)
Spray booth filters	235,974	(62,338)	196,645	(51,948)	176,980	(46,753)	147,484	(38,961)
Waterwash booth sludge[g]	46,903	(12,390)	49,970	(13,201)	35,911	(9,487)	37,605	(9,934)
Total solid waste	376,681	(99,509)	335,451	(88,617)	284,714	(75,213)	251,942	(66,556)

[a] The sets of values were calculated in metric units, then converted to English units using the conversion factor 1 liter (ℓ) equals 0.2641721 gallons (gal).

[b] Solid wastes include wastes generated by solids overspray, filter material and sludge from waterwash spray booths.

[c] Regulatory Alternatives I-25, II-25, III-25, V-25, VI-25, VII-25, VIII-25, X-25, XI-25, XII-25, XIV-25, and XV-25.

[d] Regulatory Alternatives IV-25, IX-25, XIII-25 and XVI-25.

[e] Regulatory Alternatives I-25/40, II-25/40, III-25/40, V-25/40, VI-25/40, VII-25/40, VIII-25/40, X-25/40, XI-25/40, XII-25/40, XIV-25/40, and XV-25/40.

[f] Regulatory Alternatives IV-25/40, IX-25/40, XIII-25/40, and XVI-25/40.

[g] Solids from coating overspray is not included in sludge volume since it was accounted for in solids overspray.

TABLE 7-9. EXAMPLES OF HAZARDOUS SUBSTANCES USED IN THE SURFACE COATING PROCESS

Substance	Associated process	Exposure limits TLV[a,5] (mg/m³)	Exposure limits PEL[b,6] (mg/m³)	Comments
Organic solvents (VOC)	Use of organic-solvent-based coatings	Varies[c]	Varies[c]	
Toluene-2, 4-diisocyanate	Use of some two-component catalyzed urethanes	0.04	0.14	
Aluminum oxide	Grit blasting prior to zinc-arc spray	10 (5)[d]	15	
Zinc oxide fume	Zinc-arc spray	5	5	
Nickel metal	Use of nickel-filled EMI/RFI shielding coatings	1	1	Suspected carcinogen[7]
Soluble nickel compounds	Electroless plating for EMI/RFI shielding	0.1	1	Suspected carcinogen[7]

[a] Threshold Limit Value. An 8-hour time-weighted average.
[b] Permissable Exposure Limit. An 8-hour time-weighted average.
[c] Exposure limits vary depending on the specific compounds.
[d] Exposure limit for respirable dust.

7.7 REFERENCES FOR CHAPTER 7

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2. Plastics in Business Machines Growing. Plastics World. 40:10. July 1982.

3. Memo from Duletsky, B., J. Larson, and D. Newton, MRI, to the Project File. September 12, 1984. Calculation of the number of structural foam spray coating facilities covered by an NSPS.

4. Von Hor, R. C. The Processor's View of Relative Costs of the New Technology Paints for Structural Foam Products, Ex-Cell-O Corporation, Athens, Tennessee. (Presented at the SPI Structural Foam Conference. Atlanta. April 18-20, 1983). 23 p.

5. TLV Threshold Limit Values for Chemical Substances in the Work Environment Adopted by ACGIH for 1983-84. American Conference of Governmental Industrial Hygienists. 1983. pp. 10-35.

6. U.S. Occupational Safety and Health Administration. Code of Federal Regulations. Title 29, Chapter XVII, Subpart Z, Section 1910.1000. Washington, D.C. Office of the Federal Register. March 11, 1983.

7. U.S. Department of Health, Education, and Welfare, National Institute for Occupational Safety and Health. Criteria for a Recommended Standard . . . Occupational Exposure to Inorganic Nickel. NHEW (NIOSH) publication No. 77-164. U.S. Government Printing Office, Washington, D.C. May 1977. 282 pages.

8. COSTS

8.1 COST ANALYSIS OF REGULATORY ALTERNATIVES

The estimated cost impacts of implementing the regulatory alternatives for the model plants described in Chapter 6 are presented in this chapter. The objective of this analysis is to quantify the cost impacts associated with various levels of control of VOC emissions. The economic impact of the regulatory alternatives on surface coaters of plastic parts for business machines is presented in Chapter 9.

Capital and annualized costs are presented for each regulatory alternative. All costs are presented in January 1984 dollars.

8.1.1 New Facilities

Three model plants [small (A), medium (B), and large (C)] have been defined to include the major equipment and techniques now being used to surface coat plastic parts for business machines. The model plants are intended to reflect surface coating facilities expected to be built in the future including in-house coating operations of business machine manufacturers, contractors who perform both molding and coating of plastic parts, or job shops performing coating services only. These model plants, presented in Table 8-1, were developed on the basis of data gathered from industry and published literature. A model plant is defined as a combination of a coating application/flashoff area, drying oven(s), and the auxiliary equipment. Table 8-1 presents the baseline parameters for model plants A, B, and C, which were used for all emissions and cost calculations. The baseline, Regulatory Alternative I, reflects the level of emission control in the absence of an NSPS.

Capital investment and annual operating and maintenance (O&M) costs were calculated for all the regulatory alternatives for each model plant size. The cost calculations were performed using information supplied by coaters, coating and equipment vendors, and various published works.[1-5]

8.1.1.1 Capital Costs--Model Plants. Tables 8-2 and 8-3 show the basis for estimating capital costs for the model plants for each regulatory alternative. Table 8-2 shows the estimated costs given by industry for the conveyors (if used), spray equipment, spray booths, associated ovens, and auxiliary equipment. Land and building costs, based on purchased equipment costs, were also included in the capital cost estimates. Table 8-3 shows the installed costs for the three model plants at baseline conditions.

8.1.1.2 Annualized Costs--Model Plants. Table 8-4 shows the basis for estimating annualized costs for the model plants including the cost of the eight coatings specified in the regulatory alternatives. Table 8-5 presents the methods for calculating direct and indirect annualized operating costs. Table 8-6 shows the annualized cost estimates for the three model plants at baseline conditions, including indirect operating costs.[5]

8.1.1.3 Cost Effectiveness. The cost-effectiveness value is the annual dollar cost to control 1 megagram (ton) of VOC pollutant. The average cost-effectiveness value of each alternative was calculated by dividing the annualized cost with respect to baseline by the annual VOC emission reduction.

Tables 8-7, 8-8, and 8-9 how the average cost effectiveness values of the regulatory alternatives for model plants A, B, and C, respectively. These tables also show the total annualized cost and the cost with respect to baseline values for all the regulatory alternatives.

As shown in Table 8-7, for a small plant (model plant A), the average cost effectiveness values range from $-20,000/Mg ($-18,000/ton) for Regulatory Alternative I-25/40 to $72,000/Mg ($66,000/ton) for Regulatory Alternative IV-25.

As shown in Table 8-8, for a medium plant (model plant B), the average cost effectiveness values range from $-14,000/Mg ($-13,000/ton) for Regulatory Alternative I-25/40 to $14,000/Mg ($13,000/ton) for Regulatory Alternative II-25.

As shown in Table 8-9, for a large plant (model plant C), the average cost effectiveness values range from \$-14,000/Mg (\$-13,000/ton) for Regulatory Alternative I-25/40 to \$14,000/Mg (\$13,000/ton) for Regulatory Alternative II-25.

8.1.2 Modified/Reconstructed Facilities

Under the provisions of 40 CFR 60.14 and 60.15, an "existing facility" may become subject to standards of performance if it is modified or reconstructed. As a result of such actions, the facility would incur certain costs or savings from the conversion to the mode of operation necessary to achieve the proposed standard. Presented in Table 8-2 are the cost elements for estimating installed capital costs for a modified or reconstructed facility. Table 8-4 presents the cost elements for estimating direct operating costs for such a facility, and Table 8-5 presents the methods used for calculating annualized costs for such a facility.

8.2 OTHER COST CONSIDERATIONS

In addition to costs associated with the Clean Air Act, the surface coating industry may also incur costs as a result of other Federal rules or regulations. These impacts are discussed in this section.

8.2.1 Costs Associated with Increased Water Pollution and Solid Waste Disposal

Wastewater disposal costs arise from the wastewater generated by waterwash spray booths and by cleanup operations. Paint solids, organic solvents, and zinc solids are the primary water pollutants. Solids are skimmed or settled out of the wastewater before it is disposed of in a municipal sewer system. Costs for disposal of paint solids in a secure landfill or by incineration are also included in annual costs. The resale value of recovered zinc is included as a credit, according to the current market value of zinc. Other solid wastes include used filters from dry filter spray booths and materials associated with the cleanup of the spray areas. Costs for disposal of these wastes were also included in the annual costs. Annual costs for maintenance include labor used for booth clean-up.

8.2.2 Resource Conservation and Recovery Act

Solid waste generated by the surface coaters of plastic parts for business machines is not currently classified as hazardous or toxic under the provisions of the Resource Conservation and Recovery Act (RCRA). However, because many coaters are currently disposing of paint sludges by incineration or by burial in a secure sanitary landfill, costs are calculated for disposal by these methods.

8.2.3 Occupational Safety and Health Administration Act

The cost of protective equipment required for zinc-aric spraying was included in the estimated capital cost to industry for each of the regulatory alternatives. However, no data were obtained regarding any additional cost to industry of compliance with the Occupational Safety and Health Administration Act (OSHA).

8.2.4 Resource Requirements Imposed on State, Regional, and Local Agencies

The owner or operator of a surface coating facility is responsible for making application to the State for a permit to construct and subsequently operate a new installation. The review of the applications, and any later enforcement action, would be handled by local, State, or regional regulatory agencies. Since it is projected that 216 plants will be subject to an NSPS in 1990 and that these plants will be scattered throughout the United States, the promulgation of standards for the surface coaters of plastic parts for business machines should not impose major resource requirements on the regulatory agencies.

TABLE 8-1. MODEL PLANT PARAMETERS[a,b]

Parameter	Plant A	Plant B	Plant C
A. Production			
1. Total volume of coating used at capacity, ℓ/yr (gal/yr)	19,409 (5,127)	155,202 (41,000)	388,030 (102,507)
2. Total solids sprayed, ℓ/yr (gal/yr)	6,420 (1,696)	51,368 (13,570)	128,424 (33,926)
3. Total solids applied, ℓ/yr (gal/yr)[c]	1,730 (457)	13,836 (3,655)	34,591 (9,138)
B. Operating Parameters			
1. Period of Operation			
a. h/d	16	16	16
b. d/wk	5	5	5
c. wk/yr	50	50	50
C. Process Parameters			
1. Type and amount of coatings used at baseline emission level			
a. Solvent-based nickel-filled acrylic for EMI/RFI shielding containing 15%, by volume, solids at the gun (17.1% of total coating consumption)			
i. Volume of coating sprayed, ℓ/yr (gal/yr)	3,331 (880)	26,498 (7,000)	66,270 (17,507)
ii. Volume of VOC sprayed, ℓ/yr (gal/yr)	2,831 (748)	22,523 (5,950)	56,329 (14,881)
iii. Volume of solids applied, ℓ/yr (gal/yr)[c]	250 (66)	1,987 (525)[d]	4,970 (1,313)[d]
b. Solvent-based two-component catalyzed urethane containing 32%, by volume, solids at the gun (53.7% of total coating consumption)			
i. Volume of coating sprayed, ℓ/yr (gal/yr)	10,410 (2,750)	83,279 (22,000)	208,198 (55,000)
ii. Volume of VOC sprayed, ℓ/yr (gal/yr)	7,079 (1,870)	56,630 (14,960)	141,574 (37,400)
iii. Volume of solids applied, ℓ/yr (gal/yr)[c]	833 (220)	6,662 (1,760)	16,656 (4,400)
c. Solvent-based two-component catalyzed urethane containing 50%, by volume, solids at the gun (19.5% of total coating consumption)			
i. Volume of coating sprayed, ℓ/yr (gal/yr)	3,785 (1,000)	30,283 (8,000)	75,708 (20,000)
ii. Volume of VOC sprayed, ℓ/yr (gal/yr)	1,893 (500)	15,142 (4,000)	37,854 (10,000)
iii. Volume of solids applied, ℓ/yr (gal/yr)[c]	473 (125)	3,785 (1,000)	9,464 (2,500)
d. Waterborne acrylic containing 37%, by volume, solids at the gun, and 12.6%, by volume, organic solvent at the gun (9.7% of total coating consumption)			
i. Volume of coating sprayed, ℓ/yr (gal/yr)	1,882 (497)	15,142 (4,000)	37,854 (10,000)
ii. Volume of VOC sprayed, ℓ/yr (gal/yr)	237 (63)	1,908 (504)	4,770 (1,260)
iii. Volume of solids applied, ℓ/yr (gal/yr)[c]	174 (46)	1,401 (370)	3,502 (925)

(continued)

TABLE 8-1. (continued)

Parameter	Plant A	Plant B	Plant C
2. Zinc consumption for zinc-arc EMI/RFI shielding			
a. Total zinc sprayed, kg/yr (lb/yr)	0	65,305 (144,101)	130,517 (288,000)
b. Zinc solids applied, kg/yr (lb/yr)	0	3[illegible],612 (76,374)	69,174 (152,640)
3. Coating equipment			
a. Conveyorized lines	0	1	2
b. Manual air atomized spray guns	2	5	9
c. Dry filter spray booths[e]	2	5 (2 batch; 3 on conveyorized line)	6 (2 batch; 4 on conveyorized line No. 1)
d. Waterwash spray booths[e]	0	0	3 (3 on conveyorized line No. 2)
e. Spray booth ventilation rate, m³/s (acfm)	4.7 (10,000)	4.7 (10,000)	4.7 (10,000)
f. Grit blasting booths[f]	0	2	4
g. Zinc-arc spray booths[g]	0	2	4
h. Gas-fired intermediate bake ovens	0	0	1 (Conveyorized line No. 2)
i. Gas-fired final curing ovens	1	2 (1 batch oven; 1 multiple pass oven on conveyorized line)	2 (1 batch oven; 1 multiple pass oven through which both conveyor lines pass)
4. Coating application			
a. Average transfer efficiency			
i. Prime and color coats	25%	25%	25%
ii. Texture and touch-up coats	25%	25%	25%
iii. EMI/RFI nickel-filled shielding coat	50%	50%	50%
b. Average dry film thickness for EMI/RFI shielding coats			
i. Metal-filled coatings	2 mil	2 mil	2 mil
ii. Zinc-arc spray	3 mil	3 mil	3 mil
c. Average dry film thickness for exterior coats			
i. Prime/filler coat	2 mil	2 mil	2 mil
ii. Color coat	1 mil	1 mil	1 mil
iii. Texture coat	3 mil[h]	3 mil[h]	3 mil[h]
iv. Total exterior film thickness applied	6 mil	6 mil	6 mil
d. Average flash-off period			
i. EMI/RFI shielding	Variable	12 min	12 min
ii. Prime/filler coat	Variable	12 min	12 min
iii. Color coat	Variable	12 min	12 min
iv. Texture coat	Variable	12 min	12 min
e. Curing temperature and time in intermediate bake oven			
i. Prime/filler coat	N/A[i]	N/A	120°F for 10 min
ii. Color coat	N/A	N/A	120°F for 10 min
f. Curing temperature and time in final curing oven	140°F for 30 min	140°F for 30 min	140°F for 30 min
g. Average conveyor speed, m/s (ft/min)	N/A	0.04 (8)	0.04 (8)

(continued)

TABLE 8-1. (continued)

Parameter	Plant A	Plant B	Plant C
D. VOC Emissions			
1. Total solvent (VOC) emissions, Mg/yr (t/yr)	10.6 (11.7)	85 (94)	212 (234)
a. Percent VOC emissions from spray booths	80	80	80
b. Percent VOC emissions from flash-off areas	10	10	10
c. Percent VOC emissions from ovens	10	10	10

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[a] The sets of values in the table were calculated by column in English units, then converted to metric units. The conversion factors used were: (a) 1 gallon (gal) equals 3.7854118 liter (ℓ); and (b) 1 Megagram (Mg) equals 1.1025 tons.

[b] Assume VOC density of 0.882 kg/ℓ (7.36 lb/gal).

[c] Assuming 25 percent transfer efficiency for exterior coats and 50 percent transfer efficiency for EMI/RFI nickel-filled shielding coats.

[d] Does not include coating solids applied by zinc arc spraying.

[e] Does not include spray booths for grit blasting stations or zinc-arc spraying stations.

[f] Includes dry filter spray booth and grit blaster.

[g] Includes waterwash spray booth and zinc-arc spray apparatus

[h] Film thickness for texture coat cannot be measured because it is a spatter coating. The value is based on the assumption that the volume of coating used for texture is spread uniformly over the surface areas coated.

[i] N/A = Not applicable.

TABLE 8-2. BASIS FOR ESTIMATING INSTALLED CAPITAL COSTS FOR SURFACE COATING OF PLASTIC PARTS USED IN BUSINESS MACHINES[5]

Cost element	Installed cost, $
Conveyor @ $246.06/meter ($75/linear foot)[a]	90,000
Spray equipment	
Air spray (gun, pump and hoses)	1,200
Air-assisted/airless spray (gun, pump, and hoses)	2,500
Electrostatic spray (gun, pump, and hoses)	4,300
Agitator (for metal-filled coatings)	350
Stainless steel parts (for waterborne coatings)	100
Proportioning system (for higher solids exterior coatings)	3,500
Electrically isolated paint supply (for spraying waterborne coatings electrostatically)	600
Dry filter spray booth	
Booths, motors and initial filters	
Plant A	2 for 7,500
Plant B	5 for 17,850
Plant C	6 for 21,000
Waterwash spray booth	
Booth and motor	13,050
Zinc-arc spray station	
Grit blaster	13,500
Zinc-arc sprayer	8,800
Waterwash spray booth and motor	13,050
Safety helmet and glasses	900
Total	36,250
Direct-fired gas oven	
Batch oven (Plants A, B, and C)	20,000
Final conveyorized oven (Plant B)	135,000
Final conveyorized oven (Plant C)	135,000
Intermediate conveyorized oven (Plant C)	135,000
Land and building	(0.53)(purchased equipment cost)[b]

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[a] Based on industry and vendor data, assume average total conveyor length of 366 m (1,200 ft).

[b] Purchased equipment cost = (total installed equipment cost ÷ 1.35).

TABLE 8-3. INSTALLED CAPITAL COSTS FOR REGULATORY ALTERNATIVE I-25--BASELINE[5]

Cost item	Plant A	Plant B	Plant C
1. Equipment costs			
Conveyor (1,200 ft/line)			
number:	0	1	2
cost, $:	0	90,000	180,000
Air spray equipment			
Guns, pumps, hoses			
number:	2	5	9
cost, $:	2,400	6,000	10,800
Agitator			
number:	1	1	2
cost, $:	350	350	700
Stainless steel parts			
number:	1	1	1
cost, $:	100	100	100
Dry filter spray booths			
number:	2	5	6
cost, $:	7,500	17,850	21,000
Waterwash spray booths			
number:	0	0	3
cost, $:	0	0	39,150
Zinc-arc spray stations			
number:	0	2	4
cost, $:	0	72,500	145,000
Direct-fired gas ovens			
Batch			
number:	1	1	1
cost, $:	20,000	20,000	20,000
Conveyorized			
number:	0	1	2
cost, $:	0	135,000	270,000
Total installed equipment costs, $:	30,400	341,800	686,800
Purchased equipment costs, $: (total installed ÷ 1.35)	22,500	253,200	508,700
2. Direct costs			
Land and building, $: (0.53)(purchased equipment)	11,900	134,200	269,600
3. Total installed costs	42,300	476,000	956,400

TABLE 8-4. BASIS FOR ESTIMATING DIRECT OPERATING COSTS FOR SURFACE COATING OF PLASTIC PARTS USED IN BUSINESS MACHINES[5]

Cost element	Cost per unit specified, $
Labor	
Operator[a]	9.83/person-h
Supervisory[b]	15% of direct operating labor
Raw materials[c]	
Organic-solvent-based two-component catalyzed urethane coating containing 32%, by volume, solids at the gun	18/gal at the gun
Organic-solvent-based two-component catalyzed urethane coating containing 50%, by volume, solids at the gun	25/gal at the gun
Organic-solvent-based two-component catalyzed urethane coating containing 60%, by volume, solids at the gun	35/gal at the gun
Waterborne acrylic coating containing 32%, by volume, solids at the gun	20/gal at the gun
Organic-solvent-based nickel-filled acrylic EMI/RFI shielding coating containing 15%, by volume, solids at the gun	32/gal at the gun
Organic-solvent-based nickel-filled urethane EMI/RFI shielding coating containing 25%, by volume, solids at the gun	85/gal at the gun
Waterborne acrylic EMI/RFI shielding coating containing 33%, by volume, solids at the gun	90/gal at the gun
Zinc wire	1/lb
Maintenance	
Labor[a]	9.83/person-h
Materials[c]	As needed[d]
Utilities[e]	
Electricity	0.056/kWh
Natural gas	3.13 Mcf
Waste disposal[c,f]	60/55-gal drum

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[a] Average of BLS hourly wages for SIC codes 3471, 3479, and 3079 in November 1983 dollars.

[b] Based on GARD manual, p. 3-12.

[c] Based on vendor and industry information.

[d] Cost is dependent on size of plant and amount of spray application equipment.

[e] Average of BLS regional utility costs in January 1984 dollars.

[f] Approximate cost to incinerate or landfill solid waste. Does not include transportation fees.

TABLE 8-5. METHODS FOR CALCULATING ANNUALIZED COSTS FOR PLASTIC PARTS USED IN BUSINESS MACHINES[5]

Cost item	Method of calculation
Direct operating costs	
Labor[a]	
Operator	
Model Plant A	
Non-ZA alternatives[b]	(1.5 person/booth)(4,000 h/yr)($9.83/person-h)(No. DF booths)
ZA alternatives[c]	(1.5 person/booth)(4,000 h/yr)($9.83/person-h)(No. DF booths)(1.34[d])
Model Plant B	
Non-ZA alternatives	(1.5 person/booth)(4,000 h/yr)($9.83/person-h)(No. DF booths) + (3.5 person/ZA station)(4,000 h/yr)($9.83/person-h)(No. ZA stations)
ZA alternatives	(1.5 person/booth)(4,000 h/yr)($9.83/person-h)(No. DF booths + 1/4[e]) + (3.5 person/ZA station)(4,000 h/yr)($9.83/person-h)(No. ZA stations)
Model Plant C	
Non-ZA alternatives	(1.5 person/booth)(4,000 h/yr)($9.83/person-h)(No. DF + WW booths) + (3.5 person/ZA station)(4,000 h/yr)($9.83/person-h)(No. ZA stations)
ZA alternatives	(1.5 person/booth)(4,000 h/yr)($9.83/person-h)(No. DF + WW booths-1[f]) + (3.5 person/ZA station)(4,000 h/yr)($9.83/person-h)(No. ZA stations)
Supervisor	15% of direct operating labor
Raw materials	See Attachment B of reference 5

(continued)

TABLE 8-5. (continued)

Cost item	Method of calculation
Maintenance[g,h]	
Labor	[(3.43 person-h/booth/d)(250 d/yr) ($9.83/person-h)(No. DF booths) + (0.75)($25,000/yr)(No. WW booths)] $\left[\frac{1/TE_1-1}{1/TE_2-1}+1\right]$[i] [1/2] + ($944/yr)(No. ovens) + ($27,179.225/yr/ZA station)(No. ZA stations)
Materials	[($18.79/day/DF booth)(250 d/yr) (No. DF booths + No. ZA stations) + ($6,250/yr/WW booth)(No. WW booths + No. ZA stations)] $\left[\frac{1/TE_1-1}{1/TE_2-1}+1\right]$[1/2]
Utilities	
Electricity[j]	(5 hp/booth)(0.7457 kW/hp)(4,000 h/yr) (No. booths)($0.056/kWh) ÷ 0.90
Natural gas	[(10^6 ft^3/mo/conveyorized oven)(No. conveyorized ovens) + (10^5 ft^3/mo/batch oven)(No. batch ovens)](12 mo/yr)($3.13/Mcf)
Waste disposal	1/2[($11,330/DF booth/yr)(No. DF booths + No. ZA stations)] $\left[\frac{1/TE_1-1}{1/TE_2-1}+1\right]$ + sludge disposal charge[k]
Indirect operating costs	
Overhead[l]	80% of the sum of operating, supervisory, and maintenance labor
Taxes[l]	1% of capital costs
Insurance[l]	1% of capital costs
Administration[l]	2% of capital costs
Capital recovery[m]	13.147% of capital costs

(continued)

TABLE 8-5. (continued)

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[a] Labor costs decrease by 33 percent for exterior coating operations for regulatory alternatives involving the use of higher solids exterior coatings.

[b] Regulatory alternatives (-25 and -25/40 alternatives) allowing VOC-emitting EMI/RFI shielding coatings: I, II, III, V, VI, VII, VIII, X, XI, XII, XIV, and XV.

[c] Regulatory alternatives (-25 and -25/40 alternatives) requiring non-VOC-emitting EMI/RFI shielding coatings: IV, IX, XIII, and XVI.

[d] Reflects 17 percent drop in labor due to elimination of spraying metal-filled EMI/RFI shielding coatings and 51 percent (3 x 17 percent) increase in labor due to extra manpower required for zinc-arc spray operations.

[e] Reflects extra labor required due to the increase in production rate per DF booth.

[f] Reflects decrease in labor required due to elimination of spraying metal-filled EMI/RFI shielding coatings.

[g] Includes maintenance costs for booths and ovens. Booth maintenance decreased by 25 percent for regulatory alternatives using improved transfer efficiency.

[h] These equations apply to non-ZA alternatives. For ZA alternatives, maintenance labor and materials is adjusted in the same manner as operator and supervisor labor. Adjustment to maintenance labor and materials is done in the following manner.

Model Plant A: multiply by 1.34;
Model Plant B: add ¼ to the number of DF booths; and
Model Plant C: substract 1 from the number of DF and WW booths.

[i] These factors are included to account for the change in cost as a function of transfer efficiency (TE). TE_1 = TE of prime and color exterior coating, and TE_2 = TE of texture and touch-up exterior coating.

[j] For large and medium model plants, add 7.5 hp/booth to account for the air make-up units.

[k] Sludge disposal is necessary for Model Plant C only. See Table C-6 for the sludge disposal charge.

[l] Based on GARD Manual, p. 3-12.

[m] Assumes 10 percent interest and 15-year equipment life.

TABLE 8-6. ANNUALIZED COSTS FOR REGULATORY ALTERNATIVE I-25[a]

Cost item	Plant A	Plant B	Plant C
1. Direct operating costs			
Labor			
Operator	117,960	570,140	1,081,300
Supervisor	17,700	85,120	162,200
Raw materials			
Exterior coatings	84,500	676,060	1,689,660
EMI/RFI shielding	28,000	368,110	848,140
Maintenance			
Labor	17,800	98,400	218,370
Materials	9,400	45,390	90,730
Utilities			
Electricity	1,860	20,880	39,440
Natural gas	3,760	41,360	78,960
Waste disposal	22,660	79,310	135,830
2. Indirect operating costs			
Overhead	122,770	603,240	1,169,500
Taxes, insurance, and administration	1,690	19,040	38,260
Capital recovery	5,560	62,580	125,730
3. Total annualized costs	433,660	2,669,630	5,678,120
4. Zinc recovery value	0	-5,420	-10,830
5. NET ANNUALIZED COST	433,660	2,664,210	5,667,290

[a] A breakdown of capital and annual costs for the model plants and each regulatory alternative is included in Reference 5.

TABLE 8-7. AVERAGE COST EFFECTIVENESS OF REGULATORY ALTERNATIVES--MODEL PLANT A

Reg. Alt.	Total annualized cost of regulatory alternative, $/yr	Cost with respect to baseline, $/yr	Total emission reduction, Mg/yr (ton/yr)	Average cost effectiveness of regulatory alternative, $/Mg ($/ton)
I-25	433,637	0	0 (0)	0 (0)
II-25	450,264	16,626	1.17 (1.29)	14,000 (13,000)
III-25	441,433	7,796	2.22 (2.44)	3,500 (3,200)
IV-25	613,651	180,013	2.48 (2.74)	72,000 (66,000)
V-25	428,137	-5,500	3.31 (3.64)	-1,700 (-1,500)
VI-25	444,763	11,126	4.47 (4.93)	2,500 (2,300)
VII-25	435,933	2,296	5.52 (6.09)	420 (380)
VIII-25	359,445	-74,192	4.84 (5.34)	-15,000 (-14,000)
IX-25	608,151	174,513	5.79 (6.38)	30,000 (27,000)
X-25	376,071	-57,566	6.01 (6.62)	-9,600 (-8,700)
XI-25	367,241	-66,396	7.06 (7.78)	-9,400 (-8,500)
XII-25	433,756	118	6.34 (6.99)	19 (17)

(continued)

TABLE 8-7. (continued)

Reg. Alt.	Total annualized cost of regulatory alternative, $/yr	Cost with respect to baseline, $/yr	Total emission reduction, Mg/yr (ton/yr)	Average cost effectiveness of regulatory alternative, $/Mg ($/ton)
XIII-25	511,785	78,148	7.32 (8.07)	11,000 (9,700)
XIV-25	450,382	16,744	7.51 (8.28)	2,200 (2,000)
XV-25	441,552	7,914	8.56 (9.44)	930 (840)
XVI-25	613,769	180,132	8.83 (9.73)	20,000 (19,000)
I-25/40	402,815	-30,822	1.52 (1.68)	-20,000 (-18,000)
II-25/40	419,441	-14,196	2.69 (2.97)	-5,300 (-4,800)
III-25/40	410,611	-23,026	3.74 (4.12)	-6,200 (-5,600)
IV-25/40	572,664	139,027	4.01 (4.42)	35,000 (31,000)
V-25/40	398,943	-34,694	4.21 (4.64)	-8,200 (-7,500)
VI-25/40	414,973	-18,665	5.38 (5.93)	-3,500 (-3,100)
VII-25/40	406,142	-27,495	6.43 (7.08)	-4,300 (-3,900)
VIII-25/40	327,498	-106,139	5.46 (6.01)	-19,000 (-18,000)
IX-25/40	568,196	134,558	6.69 (7.38)	20,000 (18,000)

(continued)

TABLE 8-7. (continued)

Reg. Alt.	Total annualized cost of regulatory alternative, \$/yr	Cost with respect to baseline, \$/yr	Total emission reduction, Mg/yr (ton/yr)	Average cost effectiveness of regulatory alternative, \$/Mg (\$/ton)
X-25/40	344,124	-89,513	6.62 (7.30)	-14,000 (-12,000)
XI-25/40	335,294	-98,343	7.67 (8.46)	-13,000 (-12,000)
XII-25/40	402,916	-30,721	6.68 (7.36)	-4,600 (-4,200)
XIII-25/40	469,674	36,036	7.94 (8.75)	4,500 (4,100)
XIV-25/40	419,542	-14,095	7.85 (8.65)	-1,800 (-1,600)
XV-25/40	410,688	-22,949	8.89 (9.80)	-2,600 (-2,300)
XVI-25/40	572,741	139,104	9.16 (10.10)	15,000 (14,000)

TABLE 8-8. AVERAGE COST EFFECTIVENESS OF REGULATORY ALTERNATIVES--MODEL PLANT B

Reg. Alt.	Total annualized cost of regulatory alternative, $/yr	Cost with respect to baseline, $/yr	Total emission reduction, Mg/yr (ton/yr)	Average cost effectiveness of regulatory alternative, $/Mg ($/ton)
I-25	2,664,596	0	0 (0)	0 (0)
II-25	2,797,598	133,002	9.35 (10.30)	14,000 (13,000)
III-25	2,726,985	62,388	17.74 (19.55)	3,500 (3,200)
IV-25	2,764,995	100,399	19.86 (21.90)	5,100 (4,600)
V-25	2,620,592	-44,004	26.44 (29.15)	-1,700 (-1,500)
VI-25	2,753,594	88,998	35.79 (39.45)	2,500 (2,300)
VII-25	2,682,980	18,384	44.18 (48.70)	410 (380)
VIII-25	2,511,522	-153,074	38.73 (42.69)	-4,000 (-3,600)
IX-25	2,720,991	56,395	46.31 (51.04)	1,200 (1,100)
X-25	2,644,524	-20,072	48.08 (52.99)	-420 (-380)
XI-25	2,573,910	-90,686	56.47 (62.24)	-1,600 (-1,500)
XII-25	2,665,449	853	50.75 (55.94)	17 (15)

(continued)

TABLE 8-8. (continued)

Reg. Alt.	Total annualized cost of regulatory alternative, $/yr	Cost with respect to baseline, $/yr	Total emission reduction, Mg/yr (ton/yr)	Average cost effectiveness of regulatory alternative, $/Mg ($/ton)
XIII-25	2,642,443	-22,153	58.59 (64.59)	-380 (-340)
XIV-25	2,798,451	133,855	60.10 (66.25)	2,200 (2,000)
XV-25	2,727,814	63,218	68.49 (75.50)	920 (840)
XVI-25	2,765,848	101,252	70.61 (77.84)	1,400 (1,300)
I-25/40	2,488,937	-175,659	12.18 (13.43)	-14,000 (-13,000)
II-25/40	2,621,939	-42,657	21.53 (23.73)	-2,000 (-1,800)
III-25/40	2,551,325	-113,271	29.92 (32.98)	-3,800 (-3,400)
IV-25/40	2,590,038	-74,558	32.05 (35.33)	-2,300 (-2,100)
V-25/40	2,453,184	-211,412	33.67 (37.11)	-6,300 (-5,700)
VI-25/40	2,586,186	-78,411	43.02 (47.42)	-1,800 (-1,700)
VII-25/40	2,515,572	-149,024	51.41 (56.67)	-2,900 (-2,600)
VIII-25/40	2,326,862	-337,734	43.65 (48.12)	-7,700 (-7,000)
IX-25/40	2,554,285	-110,311	53.53 (59.01)	-2,100 (-1,900)

(continued)

TABLE 8-8. (continued)

Reg. Alt.	Total annualized cost of regulatory alternative, $/yr	Cost with respect to baseline, $/yr	Total emission reduction, Mg/yr (ton/yr)	Average cost effectiveness of regulatory alternative, $/Mg ($/ton)
X-25/40	2,459,864	-204,732	53.00 (58.42)	-3,900 (-3,500)
XI-25/40	2,389,250	-275,346	61.39 (67.67)	-4,500 (-4,100)
XII-25/40	2,489,624	-174,972	53.42 (58.88)	-3,300 (-3,000)
XIII-25/40	2,458,485	-206,111	63.52 (70.01)	-3,200 (-2,900)
XIV-25/40	2,622,626	-41,970	62.77 (69.19)	-670 (-610)
XV-25/40	2,551,989	-112,607	71.16 (78.44)	-1,600 (-1,400)
XVI-25/40	2,590,725	-73,871	73.28 (80.78)	-1,000 (-910)

TABLE 8-9. AVERAGE COST EFFECTIVENESS OF REGULATORY ALTERNATIVES--MODEL PLANT C

Reg. Alt.	Total annualized cost of regulatory alternative, $/yr	Cost with respect to baseline, $/yr	Total emission reduction, Mg/yr (ton/yr)	Average cost effectiveness of regulatory alternative, $/Mg ($/ton)
I-25	5,667,283	0	0 (0)	0 (0)
II-25	5,999,866	332,584	23.37 (25.77)	14,000 (13,000)
III-25	5,823,279	155,996	44.36 (48.90)	3,500 (3,200)
IV-25	6,107,964	440,681	49.67 (54.75)	8,900 (8,000)
V-25	5,557,319	-109,964	66.08 (72.84)	-1,700 (-1,500)
VI-25	5,889,903	222,620	89.45 (98.60)	2,500 (2,300)
VII-25	5,713,315	46,033	110.44 (121.73)	420 (380)
VIII-25	5,425,205	-242,077	96.78 (106.69)	-2,500 (-2,300)
IX-25	5,998,000	330,718	115.75 (127.59)	2,900 (2,600)
X-25	5,757,789	90,507	120.16 (132.45)	750 (680)
XI-25	5,581,201	-86,081	141.14 (155.58)	-610 (-550)
XII-25	5,669,354	2,072	126.83 (139.80)	16 (15)

(continued)

TABLE 8-9. (continued)

Reg. Alt.	Total annualized cost of regulatory alternative, $/yr	Cost with respect to baseline, $/yr	Total emission reduction, Mg/yr (ton/yr)	Average cost effectiveness of regulatory alternative, $/Mg ($/ton)
XIII-25	5,947,279	279,997	146.46 (161.44)	1,900 (1,700)
XIV-25	6,001,938	334,656	150.20 (165.57)	2,200 (2,000)
XV-25	5,825,326	158,044	171.19 (188.70)	920 (840)
XVI-25	6,110,036	442,753	176.50 (194.55)	2,500 (2,300)
I-25/50	5,247,521	-419,761	30.45 (33.57)	-14,000 (-13,000)
II-25/40	5,580,105	-87,177	53.83 (59.33)	-1,600 (-1,500)
III-25/40	5,403,517	-263,765	74.81 (82.46)	-3,500 (-3,200)
IV-25/40	5,683,545	16,263	80.12 (88.32)	200 (180)
V-25/40	5,158,176	-509,107	84.14 (92.75)	-6,100 (-5,500)
VI-25/40	5,490,760	-176,523	107.51 (118.51)	-1,600 (-1,500)
VII-25/40	5,314,172	-353,111	128.50 (141.64)	-2,700 (-2,500)
VIII-25/40	4,982,946	-684,336	109.09 (120.25)	-6,300 (-5,700)
IX-25/40	5,594,200	-73,083	133.81 (147.50)	-550 (-500)

(continued)

TABLE 8-9. (continued)

Reg. Alt.	Total annualized cost of regulatory alternative, $/yr	Cost with respect to baseline, $/yr	Total emission reduction, Mg/yr (ton/yr)	Average cost effectiveness of regulatory alternative, $/Mg ($/ton)
X-25/40	5,315,530	-351,752	132.46 (146.01)	-2,700 (-2,400)
XI-25/40	5,138,943	-528,340	153.45 (169.14)	-3,400 (-3,100)
XII-25/40	5,249,212	-418,071	133.50 (147.15)	-3,100 (-2,800)
XIII-25/40	5,500,363	-166,920	158.76 (175.00)	-1,100 (-950)
XIV-25/40	5,581,796	-85,487	156.87 (172.92)	-550 (-490)
XV-25/40	5,405,184	-262,098	177.86 (196.05)	-1,500 (-1,300)
XVI-25/40	5,685,260	17,977	183.17 (201.91)	98 (89)

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9. ECONOMIC IMPACTS

9.1 PROFILE OF INDUSTRY--SURFACE COATING OF PLASTIC PARTS FOR BUSINESS MACHINES

9.1.1 Introduction

This profile focuses on the process of surface coating plastic parts for use in business machines. For a variety of reasons, the surface coating of plastic parts for use in business machines is not a truly cohesive industry but is a collection of similar processes. Nevertheless, economic data for this activity can be developed. This affects the discussions presented here in two ways. First, the format of this profile would ideally follow a particular model of industrial organization that characterizes an industry in terms of its basic conditions, market structure, market conduct, and market performance.[1] In this profile, however, because the focus is on a process rather than a clearly delineated industry, a clear characterization of the economic factors may not be possible. Second, there are little publicly available economic data on the surface coating of plastic parts for business machines. To overcome informational shortcomings, this profile incorporates data on the industries that employ these particular processes. Although this approach may enrich the following discussions, it cannot provide precise values for many meaningful economic variables.

The purpose of this profile is to provide the reader with an economic overview of both the surface coating processes and those industries involved in the markets for plastic business machine parts. It is organized into five major sections.

9.1.1.1 Description of the Surface Coating Process and Relevant Industries. Molded plastic business machine parts are surface-coated to meet decorative, protective, and electromagnetic or radio interference shielding requirements and to prevent electrostatic discharge. Surface coating operations are performed within several industries, including business machine manufacturers, independent plastic molders and coaters, and "coating only" shops. Business machine manufacturers are represented in the following standard industrial classification (SIC) codes: SIC 3573, electronic computing equipment; SIC 3574, calculating and accounting machines; and SIC 3579, office machines. Independent plastic molders/coaters are classified in SIC 3079, miscellaneous plastic products. The coating only firms are represented in SIC 3471, electroplating, plating, and polishing, and SIC 3479, coating, engraving, and allied services. Two other industries relevant to the surface coating process are the plastics and coatings suppliers. These suppliers are included in SIC 2821, plastics and resins, and SIC 2851, paints and allied products.[2]

As mentioned above, several factors make it difficult to analyze the surface coating of plastic business machine parts as an industry unto itself. First, the surface coating of plastic business machine parts represents an intermediate step in the production of business machines. Second, these surface coating operations are not classified within the representative industries listed above, even at the seven-digit SIC level. In the context of all surface coating applications, regardless of the final product, the surface coating of plastic business machine parts accounts for only a portion of 1 application, which represents less than 5 percent of all applications.[3] Third, it appears that individual existing markets are so small and specialized that publicly available data on them do not exist.

9.1.1.2 The Surface Coating Process in the Macroeconomy. Because no specific figures are available concerning value of shipments, value-added, employment, or new capital expenditures for these U.S. surface coating operations, it is difficult to assess their absolute and relative sizes. To overcome these data limitations, this section provides ranges of probable values for different economic variables by using available data on the industries in which the surface coating process is performed.

Based on our analysis of the market for surface coating of plastic parts for business machines (see Table 9-12), we estimate the total market to range from $402,000,000 to $546,000,000 (1984 $) depending on the regulatory alternative adopted. These values represent estimated total revenue for 1990. In terms of the entire U.S. economy, these figures represent less than 0.02 percent of the 1984 U.S. gross national product (GNP).[4]

The relative sizes of employment, value-added, and capital expenditures devoted to surface coating plastic business machine parts are not known. The size of these variables for the surface coating process, however, is represented by a very small unknown fraction of these variables for the industries in which surface coating is performed. The variables for these industries are shown in Table 9-1. Note that these industry figures are 1981 values represented as a percentage of overall U.S. economic activity.

9.1.2 Basic Conditions

The supply and demand conditions for surface coating operations reflect decisions made by suppliers of this process in light of production methods, costs, and requirements; they reflect decisions made by demanders of this process regarding the attributes provided by the surface coating process and prevailing government regulations. The discussions in this section are not meant to restate the material presented in Chapter 3. Rather, these discussions provide an economic perspective on the various factors affecting the surface coating of plastic business machine parts.

9.1.2.1 Supply Conditions. The surface coating of plastic business machine parts, as previously mentioned, is performed for several general purposes. First, coatings are used to enhance the exterior finish of the plastic parts and to help improve the resistance characteristics of the parts to various forms of deterioration. Second, coatings are used to provide electromagnetic interference/radio frequency interference (EMI/RFI) shielding of plastic parts as required by Federal Communications Commission (FCC) regulations.

TABLE 9-1. RELATIVE SIZE OF INDUSTRIES RELATED TO THE SURFACE COATING OF PLASTIC BUSINESS MACHINE PARTS (1981)

Industry	Industry employment, % of total U.S. employment	Industry value-added, % of GNP	New capital expenditures, % of gross domestic private investment
Electronic computing equipment			
SIC 3573	0.32	0.60	0.45
Calculating machines			
SIC 3574	0.02	0.02	0.01
Office machines, NEC[a]			
SIC 3579	0.04	0.08	0.03
Miscellaneous plastic products			
SIC 3079	0.46	0.50	0.30
Plating and polishing			
SIC 3471	0.06	0.05	0.02
Coating and allied services			
SIC 3479	0.04	0.04	0.03

[a] NEC = Not elsewhere classified.

The majority of plastic business machine parts requires surface coating for one or both purposes stated above, although the exact percentage is unknown. Third, coatings may be used to control electrostatic discharge.

The primary inputs into the surface coating process are the various coatings, which are characterized by their use in meeting one of the three coating purposes mentioned above. Further distinctions, common to both decorative/protective and shielding coatings, are delineated by general characteristics in coating formulations.

For a firm that surface coats plastic parts, the amount and sophistication of the equipment required for the coating process are primarily a function of the type of coatings applied and the volume of production. The basic equipment used in the application step of the surface coating process is air-atomized spray equipment, which includes a pump, hoses, and a spray gun. Inexpensive and readily available from a variety of vendors, air-atomized spray equipment is used by nearly all coaters. The basic air-atomized equipment applies low-solids exterior coatings. With some additional equipment, such as agitators for nickel flake coatings, metering devices, and high-pressure pumps, air-atomized spray equipment can apply two-component higher-solids exterior coatings and conductive metal-filled shielding coatings.

The minimal capital equipment requirements necessary for the surface coating process are a single spray gun and booth, room to air-dry the coated parts, and an oven. This minimal investment level may typify the small "coating only" shops that handle small batch jobs on a per-order basis. Capital equipment investments sufficient to handle larger volumes of production are made by increasing application capacities and/or by speeding up the drying times of coated parts. Typically, larger coating facilities use more than one spray line and more spray guns per spray line and use curing ovens to speed the drying process. Further investments in capital equipment that enable larger coaters to handle even larger volumes of production involve transforming surface coating operations from a batch to a continuous production process, which is accomplished by using conveyors to carry parts through the entire surface coating process.

To protect workers and plastic parts from high concentrations of overspray and organic solvents associated with higher production volumes, larger facilities apply coatings in partially enclosed spray booths equipped with exhaust and filtration systems. Other equipment typically found in larger facilities, such as large "coating only" shops and molders/coaters, includes the specialized equipment required for zinc-arc spraying.

Because most substrate surface preparations and spraying operations are performed manually, the labor requirements per surface coating facility generally increase with production volumes. Thus, differences in employment levels at different coating facilities largely depend upon the number of spray guns used and the amount of preparation required in the surface coating process. Higher economic efficiency levels that allow increased job specialization and capital investments in the production process are associated with larger production volumes. Therefore, if production volumes are large enough, coating facilities can increase the output volume per employee by reducing the number of different tasks performed by each worker and/or by investing in the conveyorized equipment that changes production from a batch to a continuous process. Also, coating facilities can reduce their employment level per specific output volume by substituting capital for labor, such as replacing spray gun operators with robots.

In the process of surface coating of plastic parts for business machines, most production decisions are made by the machine manufacturers. Because these manufacturers specify the coatings to be applied and the application methods, the extent to which independent molders/coaters and coaters not associated with business machine production facilities can control production costs is limited. Under these circumstances, independent firms can control costs only by varying factors of production (capital and labor) or by improving technical production efficiencies at their facilities. For business machine manufacturers who surface coat their own plastic parts and for independent firms less restricted by manufacturers' specifications, other ways of controlling production costs include varying the type of coatings applied and changing the application method.

9.1.2.2 Demand Conditions. The decision on the part of business machine manufacturers to use plastic versus metal parts initiates the demand for surface coating of plastic parts. These production decisions reflect the manufacturers' desires to produce business machines with certain characteristics at the lowest possible costs. The use of plastics allows manufacturers to produce parts that are lightweight, sturdy, and less expensive than metal parts. For example, machine enclosures traditionally were made of metal; however, as of 1982, roughly 40 percent of all machine enclosures were made of plastic.[5]

Once business machine manufacturers decide to use plastic parts, their decisions concerning the production of those parts are important in determining the derived demand for surface coating. Among the chief considerations of manufacturers is the choice of molding process. Plastic business machine parts are typically molded using structural foam or straight injection techniques. Each technique currently accounts for roughly 50 percent of plastic parts produced.[6] The choice of molding technique is important to surface coating demand because structural foam molded parts, which have a large number of surface flaws, may require up to three times the amount of exterior surface coating required by straight injection molded parts. Despite its higher finishing costs, structural foam is used because it has lower tooling costs than straight injection molding. Straight injection molding does not become economically feasible unless lifetime production runs of specific parts are expected to exceed 10,000 to 20,000 units.[7]

Required physical characteristics of particular parts are another determinant of surface coating demand. Depending upon their particular use in business machines, specific plastic parts require surface coating to meet desired exterior finish, EMI/RFI shielding characteristics, or both. Exterior finish characteristics include color, texture, and resistance qualities. Given a particular molding process, the extent to which decorative surface coating is applied to enhance exterior finish characteristics depends on the degree to which manufacturers' color and texture specifications cannot be achieved by the molding process. The physical limitations of various plastic resins used to form the parts determine protective coating requirements. EMI/RFI shielding is required for many machine enclosures to meet FCC regulations. Because plastic is not a conductive material, a metallic surface coating is required to provide parts with shielding properties.

The business machine manufacturers' determinations of which coatings are applied also can affect the demand for surface coating. Increasing the solids content of coatings reduces the volume of coating sprayed. But the reduced costs associated with applying higher-solids coatings are somewhat balanced by a larger capital investment for the equipment required to apply this material and the higher cost per gallon of the coating itself.

Technical improvements in the production process of plastic business machine parts can also affect the demand for surface coating. Examples of these improvements include molded-in color and texture for straight injection molded parts and automatic mold changing machines. Use of these production techniques can effectively reduce the extent of surface coating performed or reduce production costs, although they can require substantial capital investments.

Given that a specific amount of surface coating is required, the amount of coatings used can be reduced by improving transfer efficiencies in the surface coating process. This can be accomplished by using different spray techniques, such as air-assisted airless, and electrostatic spray.

Demand for plastic business machine parts and consequently demand for the surface coating process are derived from demand for business machines. Because data are not readily available on the growth of plastics usage in business machines, the trends in demand for business machines represent the best available estimates of the historic growth in demand for the surface coating process. Table 9-2 presents the value of industry shipments in constant 1972 dollars for computing equipment (SIC 3573) and office machines (SIC 3579) from 1972 though 1983. During this 11-year period, the use of plastics in business machines became widespread. Therefore, the compounded growth rates for the two business machine categories represent conservative estimates

TABLE 9-2. HISTORICAL COMPARISON OF VALUE OF INDUSTRY SHIPMENTS FOR BUSINESS MACHINES WITH GNP IN CONSTANT 1972 $\$10^9$

Year	GNP	SIC 3573 Computing equipment	SIC 3579 Office machines, NEC[a]
1972	1,186	6.471	1.296
1973	1,254	7.422	NA[b]
1974	1,246	9.121	NA
1975	1,234	8.559	NA
1976	1,300	10.387	NA
1977	1,372	12.924	2.148
1978	1,437	16.558	NA
1979	1,479	21.466	2.366
1980	1,475	25.630	NA
1981	1,514	32.032	2.500
1982	1,485	35.700	2.380
1983	1,534	41.055	2.428

[a] NEC = Not elsewhere classified.

[b] NA = Not available.

of the growth of plastic business machine parts. The sale of computing equipment and office machines grew at a real, annually compounded rate of 18.3 and 5.9 percent, respectively, over this period. U.S. GNP, in constant 1972 dollars, is included in Table 9-2 for comparing the value of shipment figures with a measure of overall business activity. Over the 11-year period, real GNP grew at an annually compounded rate of 2.4 percent. The 18.3- and 5.9-percent growth rates for computing equipment and office machines, therefore, indicate comparatively healthy industries over this period.

9.1.3 Market Structure

This section addresses the organizational characteristics of the market(s) for the surface coating of plastic business machine parts. Because market structure characteristics influence the conduct of market participants, the economic aspects of market concentration, economies of production, integration of firms, and market entry conditions are examined here. For the most part, because of limited data, discussions in this section are generalized insights into the surface coating process.

9.1.3.1 Concentration Characteristics. As mentioned in Section 9.1.1.1, the surface coating of plastic business machine parts is performed within several industries, including business machine manufacturers and independent plastic molders/coaters and coaters. The number and distribution of these firms and their coating facilities are not known, although it has been estimated that more than 3,000 such facilities exist.[8] These coating facilities are distributed among the following number of establishments for the SIC groupings in which surface coating is typically performed:

- SIC 3573 (computing equipment): 931
- SIC 3574 (accounting machines): 64
- SIC 3574 (office machines): 215
- SIC 3079E (miscellaneous plastic products for electronic machines): 391

- SIC 3471 (plating and polishing): 3,447
- SIC 3479 (coating and allied services): 1,648.[9]

It has been estimated that six companies, listed in Table 9-3, controlled over half of the independent structural foam molding and coating market in 1982,[10] which suggests the existence of relatively large molders/coaters capable of handling large production volumes. However, these six companies do not necessarily control a majority of the surface coating market, because structural foam parts represent approximately 50 percent of plastic business machine parts produced.

A national market exists for the surface coating of plastic parts for business machines. Because the surface coating process is part of the production process of plastic parts, the size of the surface coating market depends on the extent to which business machine manufacturers produce and coat their plastic parts. When they do not perform the work themselves, machine manufacturers contract out to independent molders/coaters and coaters all or part of the production of specific parts. Typically, molders/coaters and coaters are under contract to several machine manufacturers and, conversely, machine manufacturers contract work out to several firms.

Surface coating facilities do not appear to be concentrated in any particular region of the country, with the possible exception of California. A representative list of firms that surface coat plastic business machine parts is presented in Table 9-4. Because the surface coating market is national and no apparent regional concentration exists, specific geographic locations do not provide any advantages for particular coating firms in the surface coating market.

In recent years a number of U.S. firms have moved production overseas in an attempt to become more competitive with Japaneese and other foreign rivals. Industry representatives cite lower labor costs and lower corporate tax rates as the major reasons for this trend. For example, Atari, which pays their employees at least $8 an hour plus benefits, has shifted production to Asia where workers are paid $8 a day.[11] Barbados has been successful in attracting electronics

TABLE 9-3. COMPANIES THAT CONTROLLED OVER HALF OF THE STRUCTURAL FOAM MOLDING AND FINISHING MARKET IN 1982

Company name/location
Amoco Plastics St. Paul, Minnesota
Cashiers Plastic Chandler, Arizona
Ex-Cell-O Corporation Athens, Tennessee
Leon Plastics Grand Rapids, Michigan
Poly Structures, Inc. Burlington, Massachusetts
Southeastern-Kusan, Inc. Inman, South Carolina

TABLE 9-4. REPRESENTATIVE LIST OF COMPANIES THAT PERFORM SURFACE COATING OF PLASTIC BUSINESS MACHINE PARTS

Company name/location	Company name/location
Cashiers Plastic Chandler, Arizona	Leon Plastics Grand Rapids, Michigan
Component Finishing Santa Clara, California	MDS-Qantel Corp. Hayward, California
Como Plastics Columbus, Indiana	Pitney-Bowes Stamford, Connecticut
Craddock Finishing Evansville, Indiana	Poly Structures, Inc. Burlington, Massachusetts
Eastman-Kodak Rochester, New York	Premix, Inc. North Kingsville, Ohio
E.M.A.C. Oakland, California	Southeastern-Kusan, Inc. Inman, South Carolina
E/M Lubricants Denver, Colorado	Texas Instruments Dallas, Texas
Finishing Technology, Inc. Santa Clara, California	

and computer firms such as Microdata and Intel by offering full exemption from all corporate taxes for 10 years, large cash grants for worker training, and exemption from import duties on parts and materials. Currently more than 70 countries including Korea, Taiwan, Singapore, Phillippines, India, Scotland, and Mexico are competing to attract U.S. businesses. Ireland alone has drawn almost $1 billion in fixed-asset investment from about 350 U.S. firms, including IBM, Apple, Digital Equipment, Wang Labs, and General Electric.[12]

This trend is reflected in the import and export of computer equipment by the United States in recent years. Import of computer components and peripherals doubled to $8.3 billion in 1981, while exports increased only 30 percent to $13.7 billion. The U.S. trade deficit for office business machines increased almost 400 percent, from approximately $500 million in 1980 to over $2,300 million in 1984.[13]

It is difficult to assign any degree of product differentiation to the surface coating process that is attributable to the different firms that perform these operations. Because application techniques vary only slightly and business machine manufacturers almost always specify the molding process, type of plastic, and coatings used, product differentiation is negligible for the surface coating process.

9.1.3.2 Integration of Coating Firms. Typically, the various types of firms that surface coat plastic business machine parts are vertically and/or horizontally integrated to some extent.

Firms performing surface coating operations are vertically integrated if they mold the parts they coat. Business machine manufacturers, such as Eastman-Kodak, Pitney-Bowes, and Texas Instruments, illustrate this vertical integration. Independent molders/coaters, such as those listed in Table 9-3, represent the smallest extent of vertical integration.

The extent of vertical integration among business machine manufacturers and molders/coaters results from the efforts of these firms to control production costs. Integration reduces the transaction, transportation, and production costs associated with negotiating contracts, shipping and handling parts between production stages, and scheduling discontinuities of production. These cost savings, however, are balanced against the increased investment required for combining operations.

Vertical integration among business machine manufacturers provides some advantage to the integrated firms over the lesser and nonintegrated manufacturers. Because they can mold the parts they coat, molders/coaters have an advantage over "coating only" firms. Surface coating is the last stage in production of plastic parts and the molders of these parts are more likely to maintain continual contracts with machine manufacturers than are firms that provide only finishing services.

Horizontal integration is widespread among independent molders/coaters and coaters. Typically, molders/coaters do not exclusively mold and coat plastic parts for business machines. They may produce parts for various end products such as automobiles, medical equipment, and photographic equipment. Besides plastic business machine parts, "coating only" firms typically coat other plastic parts and parts made of other substrates, e.g., metal. The extent of horizontal integration among molders/coaters and coaters reflects the applicability of these processes in the production of parts other than for business machines. As a result, the viability of these firms does not depend strictly on production of business machine parts.

9.1.3.3 Economies of Production. There is reason to believe that some production economies of scale exist among the various independent firms that surface coat plastic business machine parts.

Generally, larger firms can perform a wider range of surface coating operations and handle larger production volumes. Typically, these larger firms receive volume discounts on the coatings and equipment they purchase. Further, they are more likely to be able to afford the conveyorized equipment that allows them to surface coat parts in a continuous process, thereby avoiding scheduling discontinuities associated with batch operations. Thus, firms with large production capabilities can surface coat plastic parts at a lower average cost than can firms with smaller production capabilities.

However, these production economies of scale for the surface coating process are misleading if the overall production costs of specific plastic parts are considered. When they produce large numbers of specific parts, large molding and finishing firms enjoy a relative cost advantage over small firms. However, some of the cost advantages for large firms are lost when a larger variety of parts with smaller production runs are produced because changing molds and coatings more frequently reduces the cost savings associated with larger capital investments.

9.1.3.4 Entry Conditions. While the history of entry into the supply side of the market for surface coating services is not documented, there appear to be few barriers to entry. Capital market barriers do not appear significant because most equipment is relatively simple and inexpensive. Further, no artificial barriers, such as patent rights, government sanctions, or displacement barriers exist. Ease of entry is not hampered by product differentiation because it is negligible among firms providing surface coating services.

Vertical integration may restrict entry of new firms. A firm's ability to receive continual contracts from machine manufacturers may depend upon its ability to mold the plastic parts it coats. Without the capabilities of producing or molding specific plastic parts, companies depend upon both the machine manufacturers and the molding companies for business. However, vertical integration is not a barrier for aspiring market suppliers who already mold and coat plastic parts other than for business machines.

9.1.4 Market Conduct

This section examines the independent firms that surface coat plastic business machine parts to determine whether their conduct approximates that of a competitive pricing, monopoly pricing, or price-searching model. Examination of product homogeneity, industry concentration, and barriers to entry suggests suppliers of surface coating services are characterized by competitive pricing behavior.

The competitive pricing model suggests that suppliers of surface coating services have little or no control over the price they charge for their services. The model characterizes suppliers as price takers, whereby prices are determined by the overall market forces for these services, and firms realize only a normal profit. In this model, market structure is such that any abnormal profits realized are quickly dissipated by increased competition among suppliers, either by increased production levels of existing firms or by an increased number of new suppliers.

9.1.4.1 Concentration. Concentration of suppliers largely determines market pricing behavior. In a market characterized by many suppliers, with no one firm producing a significant share of total output, the behavior approaches that of perfect competition. Reinforcing this notion is the extremely competitive nature of the business machine markets, which causes manufacturers to work to reduce their production costs continuously. Thus, if any concentration does exist, firms are unlikely to exploit any market power in price setting due to manufacturers' searching for relative and absolute production cost advantages.

9.1.4.2 Product Homogeneity. The degree to which an industry's output is perceived by demanders to be homogeneous is an important determinant of industry pricing behavior. The more homogeneous the product, the more difficult it is to sell it at a higher price than that being offered by one or more competitors.

Because business machine manufacturers require specific characteristics of their parts and select specific coatings for specific parts, product homogeneity among firms providing coating services is extensive. The surface coating process is basically the same no matter who performs the service; as such, price differences among suppliers are the result of cost differences and not of product differentiation.

9.1.4.3 Barriers to Entry. The degree to which barriers to entry effectively reduce market penetration by new firms influences industry pricing behavior. Effective barriers to entry reduce competition and allow firms to set their own prices.

As previously mentioned, significant barriers to entry for new surface coating firms do not exist. Basic coating operations do not require substantial capital investment, which in some cases can deter new entrants. Vertical integration could be a barrier to entry, but only if molding/coating firms, which currently produce nonbusiness machine parts, are prevented from entering the surface coating market by some regulatory action.

Furthermore, because the business machine markets are so competitive "with volume going up and selling prices going down," new surface coating entrants are less apt to be hindered by traditional industry relationships.[14] Thus, the apparent lack of significant barriers promotes the selection of the competitive pricing model.

9.1.5 Market Performance

In a profile where an industry is examined in terms of its conditions, structure, conduct, and performance, performance is viewed as the end result of the causal chain. Emphasis in this section is on three aspects of market performance. First, small manufacturers of plastic parts are examined concerning financial performance. Second, recent trends among business machine manufacturers are discussed. Third, projections for the surface coating of plastic business machine parts are presented.

9.1.5.1 Financial Profile of Small Manufacturers of Plastic Parts.

Ideally, this section would present the financial performance of independent plastic molders/coaters and coaters. Unfortunately, data limitations require a proxy approach in which the average financial performance of plastic parts manufacturers with total assets less than $250,000 is discussed. These small manufacturers are believed to typify the independent firms that surface coat plastic business machine parts. The data presented in this section are meant to provide an understanding of the financial health of these firms and to indicate their fiscal capabilities in financing new capital expenditures that could result from some regulatory action.

Small manufacturers of plastic parts are examined in light of liquidity, leverage, and profitability. Liquidity refers to a firm's ability to meet cash-flow obligations as they come due. Leverage measures the degree to which a firm is financed by debt. Profitability refers to the return on total investment in the firm.

Liquidity ratios are measures of a firm's ability to meet current obligations as they come due. Two liquidity ratios are presented in this section. One, the current ratio, is computed by dividing a firm's current assets by its current liabilities. A firm with a current ratio above 2.0 is considered reasonably liquid. A firm with a current ratio below 1.0 may be unable to pay its bills on time, which may ultimately lead to its demise. The other ratio used, the quick ratio, is a more severe measure of liquidity. It subtracts inventories from current assets because inventories may be less liquid owing to physical deterioration and to the transaction costs of converting them to cash. For the quick ratio, a measure of 1.0 or greater indicates a firm's relative liquidity.

Measures of leverage indicate a relationship between debt and assets. They show how much the firm is debt-financed versus how much it is financed by equity. These measures help show the likelihood that a firm will meet its long-term obligations. Further, as a firm becomes more heavily debt-financed, it becomes increasingly difficult for it to attract new capital. The leverage ratio used in this profile is the ratio of a firm's total debt to total assets, expressed as a percentage. While every industry has its characteristic leverage ratio, typically a firm with a lower ratio has a lower burden of fixed interest payments and hence can weather recessions better than can firms with a higher ratio. However, the higher leveraged firms do better in boom times, especially if the debts were issued at low interest rates.

Profit ratios measure the firm's return on total investment and help measure its ability to pay dividends to stockholders while maintaining adequate funds to ensure growth. A ratio of 10 percent or higher is often deemed necessary to secure these ends. Two measures of profitability are presented here: first, the ratio of net (after tax) profit to total assets and, second, the ratio of net profit to shareholders' equity. Both are expressed as percentages.

Table 9-5 shows the median liquidity, leverage, and profitability measures for small manufacturers of plastic parts for the years 1979 and 1983. Exact comparisons made between these years' data are imperfect because of the different sources and assumptions made about the median values. However, the data do allow reasonably secure conclusions about the general trend in the industry.

The data indicate that these manufacturers are liquid and able to meet short-term debt obligations. These manufacturers were appreciably more liquid in 1983 than in 1979. Table 9-5 also shows a reduction in the median leverage level between 1979 and 1983, indicating a trend among these manufacturers toward greater equity and less debt financing.

Finally, from the profitability ratios, the health of small manufacturers of plastic parts appears to be good. The ratios for 1983, though down somewhat from 1979, are relatively high, which, with the reduction in the median level of the leverage ratio, indicate an overall sufficiency to attract new investment capital.

9.1.5.2 Recent Trends. Intense competition from domestic and foreign producers coupled with continuous growth in demand for business machines--especially personal and desktop terminals--has played a large role in the development of the market for surface coating of plastic business machine parts. The competitive forces of the electronic computing equipment industry have caused manufacturers to search for ways to produce less expensive machines while demand has continued to grow. Further, use of plastic parts has increased because of the need for lighter-weight, yet sturdy, materials as machines have become smaller and more portable.

These trends are illustrated by the fact that over the 9-year period, 1972 through 1981, real growth in the electronic computing equipment industry (SIC 3573) has increased at an annually compounded rate of 18.3 percent when the values of industry shipments are adjusted for inflation.[15] Comparatively, real GNP over the same period grew at the rate of 2.7 percent per year.[16] Further, the price index for SIC 3573 output showed zero growth over that period, while the GNP Implicit Price Deflator, a measure of inflation, grew at a 7.7-percent annual

TABLE 9-5. SELECTED FINANCIAL RATIOS FOR SMALL MANUFACTURERS[a] OF PLASTIC PARTS

	1979 Median (percent)	1981 Median[b] (percent)
Liquidity Ratios		
Current[c]	1.29	1.51
Quick[d]	--	1.03
Leverage Ratio		
Total debt/total assets	55.9	15.3
Profitability Ratios		
Net profit/total assets	18.5	13.6
Net profit/net worth	42.1	--

Sources: Dun and Bradstreet Corporation, Business Economics Division. Dun & Bradstreet's 1980 Key Business Ratios. 1980

Schonfeld & Associates, Inc. IRS Corporate Financial Ratios. 1984.

[a] Small manufacturers are defined in terms of net worth less than $50,000 in Dun & Bradstreet's Key Business Ratios. Small manufacturers are defined in terms of total assets less than $250,000 in the Schonfeld Corporate Financial Ratios.

[b] Median value of all firms earning a profit in 1983.

[c] Current liquidity ratio = current assets/current debt.

[d] Quick liquidity ratio = (current assets - inventories)/current debt.

rate.[17] [18] Between 1972 and 1981, demand for office machines (SIC 3579), again measured by the real value of industry shipments, grew at a faster rate than did real GNP, a 7.7-percent annually compounded growth rate compared to a 2.7-percent rate, respectively.[19] The price index for office machines (SIC 3579) climbed less steeply than did the Implicit Price Deflator, rising 5.8 percent per year compared to overall price increases of 7.7 percent per year.[20]

Further, the product price index for plastics and resins (SIC 2821) grew at a 13.7-percent compounded rate between 1972 and 1981.[21] Despite the rapid increase in plastics and resin prices, the price index for miscellaneous plastic products (SIC 3079) grew at a more modest rate of 8.8 percent, compounded annually.[22]

9.1.5.3 Projections for Surface Coating. The outlook through 1990 for the firms that surface coat plastic business machine parts appears quite good. The projected real growth of plastic business machine parts requiring surface coating through 1990 is 17.0 percent, compounded annually.[23]

Several important components are reflected in this projected growth rate. First, because demand for plastic business machine parts is derived from demand for business machines, the growth projection for business machines is the most important component of the surface coating growth rate. The projected growth rate for business machines through 1990 is 16.3 percent.[24] This figure represents a weighted average of projected real growth rates for electronic computing equipment (SIC 3573) and office machines (SIC 3579). Second, an increase of 40 to 90 percent in plastics usage in small desktop computers and terminals is expected in the next 5 years. Consequently, an increase in plastics usage in business machines above 16.3 percent is very likely.[25] [26] Third, increases in the use of plastic parts that require surface coating are mitigated somewhat by increases in imported business machines (currently projected to be 35 percent growth per year), increases in machine and parts production out of the United States, and, finally, decreases in the percentages of plastic parts requiring surface coatings.[27]

9.2 ECONOMIC EFFECTS OF REGULATORY ALTERNATIVES

This section presents the estimated economic effects of the regulatory alternatives for surface coating of plastic business machine parts. The market for plastic parts coating is subdivided in this analysis into two unrelated, competitive submarkets, one represented by model plant A, the other by model plant B. This is done because the costs of production differ substantially for the two plant types. Both model plant As and Bs are expected to be continued to be built for several reasons. Typically, the smaller plants fill a valuable niche in the surface coating market by providing flexibility in production. They can do many small jobs that a larger facility would not routinely handle. These might include prototype parts or a first production run of some parts prior to beginning large-scale production. Consequently, even though the larger model plants have lower costs, the smaller facilities will still be built and used, even at a higher cost per square meter. Total effects are based on the sum of the effects for each submarket. A third model plant type, C, is ignored here because only one new plant is expected to be constructed over the analysis period.

A New Source Performance Standard (NSPS) for surface coating services for plastic business machine parts may impose additional capital costs and increase annual operating costs or may result in a decrease in those costs. Price changes for surface coating services range from -24.4 to +41.6 percent (relative to baseline) for Market A (composed of type A model plants) and from -12.6 to +5.0 percent for Market B depending on the regulatory alternative. Quantities of surface coating services supplied for both Market A and Market B range from 23.4 to 24.6 million m^2/yr (251.8 to 264.8 million ft^2/yr) compared to a baseline of 23.6 million m^2/yr with no NSPS. Total costs to society of the NSPS range from -\$83.3 million to \$33.24 million. Employment changes vary with the market and changes in the quantities and range from -0.7 to +4.2 percent. Net changes in welfare excluding the environmental benefits range from -\$33.24 million to \$83.3 million.

9.2.1 Methodology and Data Inputs

The methodology employed to estimate the potential economic effects of the regulatory alternatives has two separate components. A model based on discounted cash flow analysis is used to compute the unit costs of plastic parts coating. Then, given these costs and other market parameters, a competitive model of the market for plastic parts coating is used to project the economic effects of the regulatory alternatives. These models are described below.

9.2.1.1 Unit Cost Estimation Model. The unit costs of NSPS for surface coating of plastic business machine parts are estimated using a discounted cash flow (DCF) analysis. Under this approach, the expected future annual costs of an investment in a surface coating facility are discounted and then annualized at an appropriate interest rate to determine the minimum price at which the investment would be profitable. This is when the net present value (NPV) of the investment is zero. This section describes the DCF methodology used.

An investment is expected to generate a series of cash inflows and outflows during its lifetime. The net cash flow in the first year (year zero) is negative because the cash outflows for the initial investment are not offset by any cash inflows. After production begins, the investment generates a stream of cash inflows of revenues from the sale of its output and depreciation of the capital investment, and cash outflows of operating expenses. Beginning with year one and continuing throughout the lifetime of the project, annual cash flows are expected to be positive, but need not be. Although cash flows may occur at any time, we assume they will take place at the end of the year. We also assume that the only investment in the project takes place at the end of year zero and is followed by a series of net cash inflows. These assumptions guarantee a unique rate of return for each project.

The cash outflow in year zero may be expressed

$$Y_o = (FCC + WC) \tag{9-1}$$

where

Y_o = Cash flow in year zero

FCC = Capital investment

WC = Working capital (E/6)

E = Total operating costs.

The project generates its first revenues at the end of its first year of production (year one). The net cash flows in this and subsequent years can be expressed

$$Y_t = (R_t - E_t)(1-T) + DTX_d, \quad \begin{array}{l} t = 1, \ldots 15 \\ d = 1,2,3,4,5 \end{array} \qquad (9\text{-}2)$$

where

Y_t = Net cash flows in year t

R_t = Total revenues in year t

E_t = Total operating costs in year t

T = Corporate income tax rate

DTX_d = Tax savings from depreciation.

The first term, $(R_t - E_t)(1-T)$, represents the net after-tax inflows of the facility generated by the sales of the output. Total revenues in year t can be expressed

$$R_t = (P \cdot Q)_t \qquad (9\text{-}3)$$

where

P = Price per unit of output

Q = Quantity of output sold during the year.

Total operating costs in year t can be expressed

$$E_t = [(V \cdot Q) + F]_t \qquad (9\text{-}4)$$

where

V = Variable cost per unit of production

F = Fixed annual cost of operating the facility.

Variable costs include expenditures on material inputs, labor, and energy. Fixed costs include such expenses as site rent (explicit or implicit), insurance, and administrative overhead.

Only net revenues are subject to the corporate income tax (T). Consequently, annual total operating cost is deducted from total revenue to yield the taxable net revenue. The firm's after-tax net revenue in year t is thus the first term in Equation (9-2).

Current Federal tax law allows accelerated depreciation of assets under the Accelerated Cost Recovery System (ACRS) formula. The depreciable base is equal to $[(1 - \frac{\text{Investment Tax Credit}}{2}) \times \text{Fixed Capital Cost}]$ or 95 percent of the Fixed Capital Cost (based on the Tax Equity and Fiscal Responsibility Act of 1982). For depreciation purposes the lifetime of the capital is 5 years, which is significantly shorter than the projected actual lifetime of the investment. Table 9-6 shows the depreciation schedule for a 5-year property under the ACRS. Along with the investment tax credit, this accelerated depreciation schedule significantly lowers the effective cost of capital to a firm.

The tax savings from depreciation expenses are defined by the expression

$$DTX_t = [FCC - (\frac{TCRED \cdot FCC}{2})] \cdot DEP_t \quad \cdot T, \qquad t = 1,2,3,4,5 \qquad (9\text{-}5)$$

where

DTX_t = Tax savings from depreciation

DEP_t = Depreciation percentage for years 1 to 5 as shown in Table 9-6.

The net cash flows represented by Equation (9-2) occur at the end of the first through the Nth years, where N is the life of the project. The investment tax credit, equal to 10 percent of the fixed capital cost, is assumed to occur in year 1. An additional cash inflow occurs at the end of the Nth year when the working capital, WC in Equation (9-1), is recovered at the end of the project. The salvage value of the plant is assumed to be zero.

The investment project is thus represented as a cash outflow in the first year followed by N cash inflows and outflows in successive

TABLE 9-6. DEPRECIATION DEDUCTIONS UNDER THE ACCELERATED COST RECOVERY SYSTEM

Year	Percentage of depreciable base
1	15
2	22
3	21
4	21
5	21

Source: Tax Guide for Small Business. Department of the Treasury. Internal Revenue Service. 1983.

years. Cash flows that occur over a future period must be discounted by an appropriate interest rate to reflect the fact that a sum of money received at some future date is worth less than an equal sum received today. The discounted value of this sum received in the future is called its present value. The discount factor is a function of both time and the interest rate and can be expressed as

$$DF_t = (1 + r)^{-t} \tag{9-6}$$

where

DF_t = The discount factor for year t

r = Interest rate.

An understanding of the discount factor and the selection of an appropriate rate of interest in practice is important. The interest rate r in Equation (9-6) can be viewed as the cost to the firm of acquiring funds for the project. The firm can acquire funds in essentially any combination of three ways. It can issue bonds, sell stock, or utilize currently held liquid assets. There is a cost associated with each method. Interest must be paid on bonds and dividends on stock, and there is an opportunity cost associated with utilizing internal funds. In the absence of specific information on how a project would be financed, a weighted average cost of capital can be used.

The discounted cash flow model is used to determine the minimum average total cost (ATC) of production. This is where the net present value of the investment is zero. This value for ATC is also the minimum price for surface coating services needed to justify investment in new facilities. The ATC values for all regulatory alternatives are calculated as follows:

$$NPV = \sum_{t=1}^{15} (Y_t \cdot DF_t) - Y_o = 0 \quad . \tag{9-7}$$

Substituting Equation (9-2) and rearranging,

$$NPV = \sum_{t=1}^{15} (R_t - E_t)\ (1-T)\quad DF_t \quad + \sum_{t=1}^{5} (DTX_t)\ (DF_t)$$

$$+ \frac{(0.1)(FCC)}{(1+r)} + \frac{WC}{(1+r)^{15}} = Y_o \quad . \tag{9-8}$$

If revenues and expenses are the same over all periods and depreciation occurs in the first 5 years only, then

$$(R-E)\ (1-T) \cdot \sum_{t=1}^{15} DF_t + \sum_{t=1}^{5} (DTX_t)\ (DF_t)$$

$$+ \frac{(0.1)(FCC)}{1+r} + \frac{WC}{(1+r)^{15}} = Y_o \quad . \tag{9-9}$$

The sum of the discount factors as t ranges from 1 to 15 can be written

$$F = \sum_{t=1}^{15} DF_t = \frac{1 - (1+r)^{-N}}{r} \tag{9-10}$$

where

F = Sum of the discount factors from 1 to 15.

Substituting Equations (9-10) and (9-1) into (9-9) yields

$$(R-E)(1-T)(F) + \sum_{t=1}^{5} (DTX_t)\ (DF_t) + \frac{(0.1)(FCC)}{(1+r)} + \frac{WC}{(1+r)^{15}} = Y_o \quad . \tag{9-11}$$

Substituting Equations (9-3) and (9-1) into Equation (9-11) and rearranging yields

$$(P \cdot Q) - E = \frac{(FCC+WC) - \sum_{t=1}^{5} (DTX_t)(DF_t) - \frac{(0.1)(FCC)}{(1+r)} - \frac{WC}{(1+r)^{15}}}{(1-T)(F)} \quad . \tag{9-12}$$

Further rearranging provides

$$P = \frac{(FCC+WC) - \sum_{t=1}^{5} (DTX_t)(DF_t) - \frac{(0.1)(FCC)}{(1+r)} - \frac{WC}{(1+r)^{15}}}{(1-T)(F)(Q)} + \frac{E}{Q} \tag{9-13}$$

where

P = ATC

First term = Capital cost per unit output including allowances for the investment tax credit and depreciation.

Second term = Operating cost per unit.

Chapter 6 identifies and discusses 32 regulatory alternatives. As shown in Table 9-7, each model plant has a unique set of fixed capital and annual operating costs based on its capacity. Consequently, the economic effects of the proposed NSPS will depend on which types of facilities are actually constructed. The costs are taken directly from tables in Chapter 8 except that annual operating cost excludes any capital recovery factor. Capital costs in Table 9-7 are used in the FCC term of Equation (9-1) and annual operating costs are employed in the E term in Equation (9-2).

Table 9-8 lists the parameter values used in the model to determine ATC. A value of working capital equal to 2 months of the annual operating costs (E/6) is assumed. Because surface coating is a labor- and materials-intensive process, the primary component of working capital is those funds tied up in raw materials inventory, payroll, utilities, and accounts receivable. This value is representative of the required working capital.

The investment tax credit is 10 percent; we assume the entire fixed capital cost is eligible for that credit. The Federal and average State marginal corporate tax rates are assumed to be 46 percent and 6 percent, respectively. Because State taxes are deductible from taxable income for Federal tax purposes, the overall effective tax rate is 49 percent. The project life is assumed to be 15 years. A discount rate of 10 percent is employed, based on Office of Management and Budget (OMB) guidelines.

In 1990, the total square feet of plastic parts surface coated is projected to be 23.6×10^6 m^2 (254×10^6 ft^2) if there were no NSPS. Of this amount, 15.4×10^6 m^2 (166×10^6 ft^2) will be produced from existing facilities and 8.2×10^6 m^2 (88×10^6 ft^2) from new facilities

TABLE 9-7. MODEL PLANT COST DATA, 1984 $\$10^6$/yr

Regulatory Alternative	Model Plant A		Model Plant B		Model Plant C	
	Capital cost	Annual operating cost	Capital cost	Annual operating cost	Capital cost	Annual operating cost
I-25 (BASELINE)	42,265	428,080	475,988	2,602,018	956,363	5,541,550
II-25	42,265	444,707	475,988	2,735,020	956,363	5,874,133
III-25	42,265	435,876	476,127	2,664,389	956,641	5,697,509
IV-25	92,259	601,522	521,596	2,696,421	1,100,775	5,963,245
V-25	42,265	422,580	475,988	2,558,014	956,363	5,431,586
VI-25	42,265	439,206	475,988	2,691,016	956,363	5,764,170
VII-25	42,265	430,376	476,127	2,620,384	956,641	5,587,545
VIII-25	49,265	352,968	489,988	2,447,103	980,863	5,296,251
IX-25	92,259	596,022	521,596	2,652,417	1,100,775	5,853,281
X-25	49,265	369,594	489,988	2,580,105	980,863	5,628,835
XI-25	49,265	360,764	490,127	2,509,473	981,141	5,452,210
XII-25	42,404	428,181	476,545	2,602,798	957,338	5,543,493
XIII-25	99,259	498,735	535,596	2,572,028	1,125,275	5,799,339
XIV-25	42,404	444,807	476,545	2,735,800	957,338	5,876,077
XV-25	42,404	435,977	476,545	2,665,163	957,477	5,699,446
XVI-25	92,399	601,621	522,153	2,697,201	1,101,750	5,965,189
I-25/40	45,886	396,782	483,230	2,425,407	967,225	5,120,360
II-25/40	45,886	413,408	483,230	2,558,409	967,225	5,452,944
III-25/40	45,886	404,578	483,369	2,487,776	967,504	5,276,319
IV-25/40	97,209	560,278	527,166	2,520,731	1,111,637	5,537,398
V-25/40	49,367	392,453	483,230	2,389,654	967,225	5,031,015
VI-25/40	45,886	408,940	483,230	2,522,656	967,225	5,363,599
VII-25/40	45,886	400,109	483,369	2,452,023	967,504	5,186,974
VIII-25/40	52,886	320,545	497,230	2,261,491	991,725	4,852,564
IX-25/40	94,209	555,810	527,166	2,484,978	1,111,637	5,448,053
X-25/40	52,886	337,171	497,230	2,394,493	991,725	5,185,148
XI-25/40	52,886	328,341	497,369	2,323,861	992,004	5,008,524
XII-25/40	46,025	396,865	483,647	2,426,039	968,061	5,121,941
XIII-25/40	101,209	456,368	541,166	2,387,338	1,136,137	5,350,995
XIV-25/40	46,025	413,491	483,647	2,559,041	968,061	5,454,525
XV-25/40	45,886	404,655	483,647	2,488,404	968,200	5,277,895
XVI-25/40	94,209	560,355	527,584	2,521,364	1,112,612	5,538,985

TABLE 9-8. MODEL PARAMETER VALUES

Parameter	Value used
Working capital (WC)	E/6
Federal investment tax credit	0.1 × FCC
Federal corporate tax rate (FT)	46%
State corporate tax rate (ST)	6%
Project life (N)	15 years
Discount rate (r)	10%

subject to the NSPS regulation. Of the total, approximately 33 percent is projected to be produced by model plant A facilities and 67 percent by model plant B facilities. Only one model plant C is expected to be built by 1990. Its output would represent only 2 percent of the total output in 1990, and is excluded from this analysis.

Because the ATC is significantly different for each model plant, we have treated the markets served by each group of model plants as if they were different. Because only one model plant C-sized facility is projected, the analysis assumes 33 percent of output is provided by type A model plants, 67 percent by type B model plants, and none by type C model plants. Effects are determined for each market and then aggregated for the total industry.

Table 9-9 shows the estimated ATC values for each regulatory alternative in each submarket. The baseline values are also shown.

9.2.1.2 Market Model. The analytic framework for the market model that is applied in this analysis depends heavily upon the work of W.E.G. Salter.[28] The framework is based on standard microeconomic theory, employs a comparative statics approach, and assumes certainty in relevant markets. Price and quantity are determined by market forces, not by individual market participants.

Overview

The approach recognizes that there are two distinctly different types of production decisions: operating decisions and investment decisions.

Operating decisions involve simply whether or not a firm with plant and equipment already in place purchases inputs to produce output. These are sometimes called short-run decisions because the decision period is sufficiently short that certain inputs, namely plant and equipment, are fixed. A profit-maximizing firm will operate existing capital if the market price for its output exceeds its unit variable costs of production. If the market price even marginally exceeds average operating cost, the producing plant will cover not only the cost of its variable inputs but will cover part of its capital cost as well. A profit-maximizing firm will not pass up an opportunity

TABLE 9-9. UNIT COST OF PRODUCTION FOR MODEL PLANTS A AND B, 1990

($/m^2)

Regulatory Alternative	Model Plant A	Model Plant B
I-25 (BASELINE)	30.69	14.64
II-25	31.86	15.37
III-25	31.24	14.98
IV-25	43.44	15.19
V-25	30.30	14.40
VI-25	31.47	15.13
VII-25	30.85	14.74
VIII-25	25.44	13.80
IX-25	43.05	14.95
X-25	26.62	14.53
XI-25	25.99	14.14
XII-25	30.69	14.64
XIII-25	36.24	14.52
XIV-25	31.87	15.37
XV-25	31.24	14.99
XVI-25	43.45	15.20
I-25/40	28.51	13.68
II-25/40	29.68	14.41
III-25/40	29.06	14.02
IV-25/40	40.58	14.23
V-25/40	28.24	13.48
VI-25/40	29.37	14.21
VII-25/40	28.74	13.82
VIII-25/40	23.19	12.79
IX-25/40	40.23	14.04
X-25/40	24.36	13.52
XI-25/40	23.74	13.13
XII-25/40	28.52	13.68
XIII-25/40	33.27	13.51
XIV-25/40	29.69	14.41
XV-25/40	29.06	14.02
XVI-25/40	40.55	14.24

Note: 1 sq meter = 10.764 sq feet.

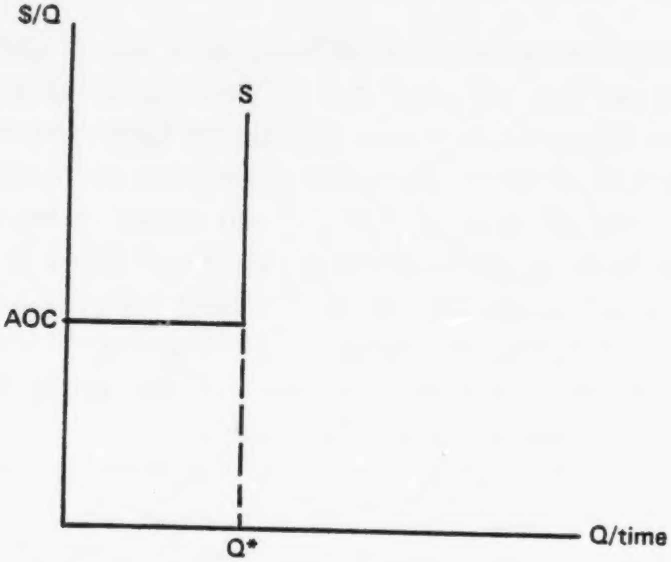
to recover even part of the initial investment it made in the plant and durable equipment and will continue to operate such a plant in the short run.

Investment decisions differ from operating decisions in that they involve whether or not the firm should put in place new plant and/or equipment. The investment decision is sometimes called a long-run decision since the time frame is sufficiently long that all inputs, including capital, are variable. A firm will not invest in new capital unless current and expected future market price is sufficient to cover both the cost of operating the new capital (variable costs) and the cost of purchasing and owning the capital, including a normal rate of return. Put differently, a firm will not invest unless market price is expected to equal or exceed average total cost.

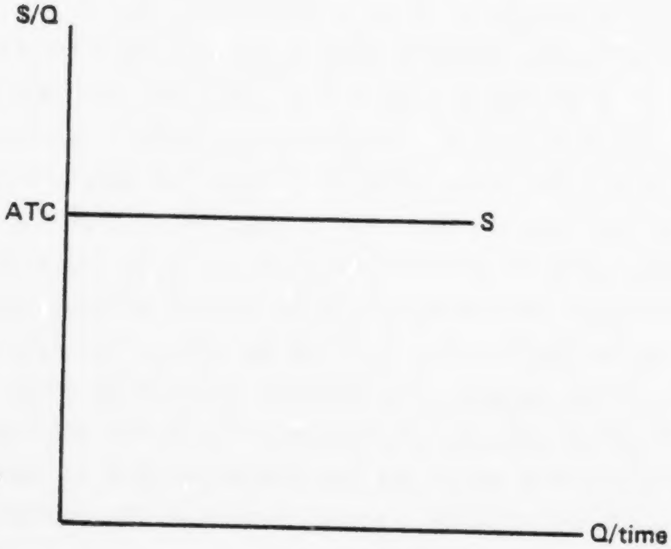
The hypothesized supply schedule from a single existing plant is depicted in panel (a) of Figure 9-1. Given the capital in place, the plant owner is willing to supply output Q* as long as market price equals or exceeds the plant's average operating cost (AOC). If market price is below AOC, the owner is unwilling to produce even a fraction of Q* because a per-unit loss would be incurred. If market price should substantially exceed AOC, the owner would be willing to produce output beyond Q* but is unable to do so given plant capacity.

The hypothesized supply schedule from an as yet unconstructed plant is depicted in panel (b) of Figure 9-1. Because the plant and equipment are not yet in place, all inputs are variable. The scale (capacity) of the plant itself is variable. Thus, the supply schedule does not turn up at any output rate. The assumption of a perfectly elastic plant supply curve is probably realistic. It is unlikely that input factor prices would be bid-up by the demands of a single plant.

Supply will not be forthcoming from the new plant, that is, it will not be built, unless market price exceeds the average total cost of production. The plant will be constructed only if the anticipated market price is sufficiently above average operating cost to recover the capital investment and provide a normal return on the capital.



(a) existing supplier



(b) new supplier

Figure 9-1. Supply schedules for constructed and unconstructed plants.

With an understanding of plant-level supply, focus is now directed toward market-level considerations. The willingness of existing plants with different average operating costs to produce at a different minimum market price results in the upward slope of the supply schedule. This is illustrated in panel (a) of Figure 9-2. The newest plant, which is of vintage n-1, has the lowest average operating cost. Thus, it is willing to supply output as long as price at least equals P_1. Plants constructed in successively earlier periods have increasingly higher average operating costs and are willing to produce only at higher prices. The oldest plant, produced in period n-5, has the highest average operating cost and is the oldest existing plant that is willing to produce at prevailing price P*; it is thus said to be a marginal plant. In panel (b) of Figure 9-2, the conventional equilibrium determination of market price and quantity is depicted. Market demand (D) is assumed to be downward sloping. The stepped supply curve for existing suppliers is smoothed and is S.

During any period of time, the market output of a good is the sum of the quantities produced by individual plants. As discussed above, once a plant is in place, it will usually produce as long as market price is equal to or greater than its average operating cost. Failure to do so would involve passing up an opportunity to earn some return on existing fixed capital.

Now that it is understood why the supply schedule is upward sloping to Q*, it is time to investigate the slope of the supply schedule beyond Q*. This is a question of long-run supply because output in excess of Q* can be produced only after a new plant has been constructed. The question then becomes, what is the market price at which a new plant will be constructed?

All costs of an unconstructed plant are variable costs. The prospective builder will invest in the new plant only if the anticipated market price is sufficiently high to cover average total cost, which is average operating cost plus average capital cost, including a normal return on the capital.

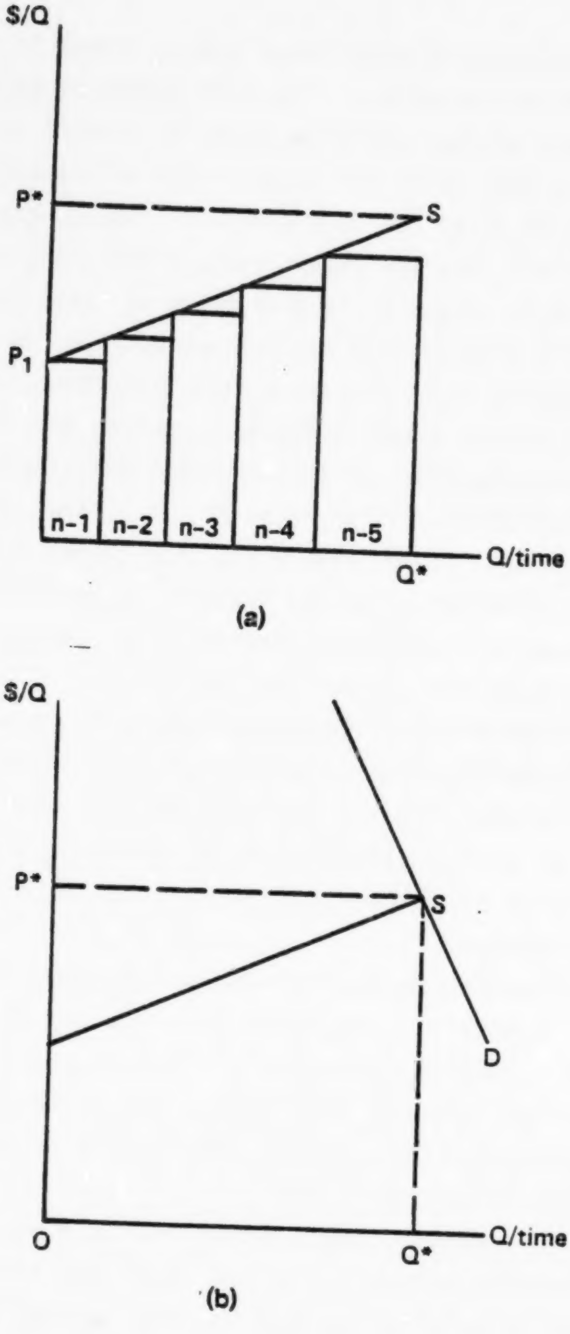


Figure 9-2. Market equilibrium.

In Figure 9-3, plant n represents the as yet unconstructed plant. In the figure, oa is the average operating cost of the new plant. The cost component aT is the average capital cost of the new plant. This cost component represents the return per unit output in excess of operating cost required to repay the principal of the original capital investment and earn a normal rate of return on that investment. The firm's desire to recover the investment principal and earn a normal return holds for both existing facilities and facilities under consideration. In the latter case though, even these costs are variable, indeed they are avoidable. The firm has the alternative of not building at all; i.e., of investing in another project. Thus, the new plant will be built only if market price equals or exceeds average total cost oT. Once built, it will supply output Q' - Q* as long as market price covers average operating cost; its capital costs become sunk. Thus, the long-run supply schedule, at least from Q* to Q', is elastic where price equals average total cost of the best technology plant.

The validity of assuming perfectly elastic long-run market supply is unknown. For relatively small increases in market output resulting from the construction of, say, only a few new facilities, the assumption is probably reasonable. If, however, the number of newly constructed facilities increased market demand for factors of production significantly, it is possible that factor prices would be bid up and that long-run supply would be upward-sloping.

Market Equilibrium Without an NSPS

Figure 9-4 shows the long-run equilibrium conditions for a plastic parts surface coating market. Demand is assumed to shift over the 1985-90 period as shown. The 1990 market-clearing price and quantity are P1 and Q2, respectively. Output Q1 represents the component of 1990 output, Q2, that is produced by suppliers that were in existence in 1985. For the purpose of this analysis, it is assumed that existing suppliers are operating at full capacity and cannot expand output beyond Q1. Additional output in excess of Q1 can be produced only if a new plant has been constructed. The price P1 represents the market

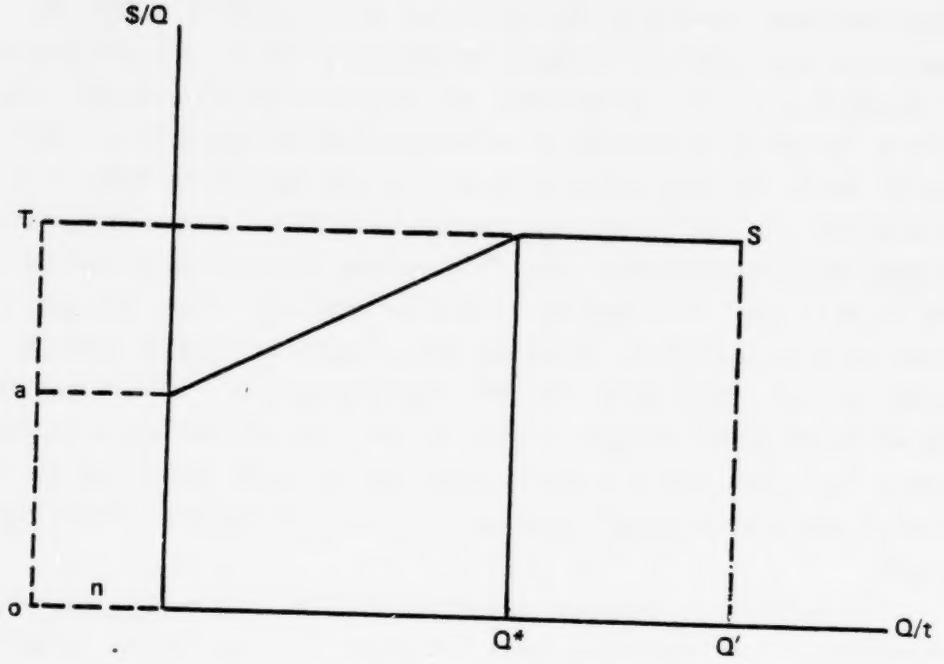


Figure 9-3. Long-run supply.

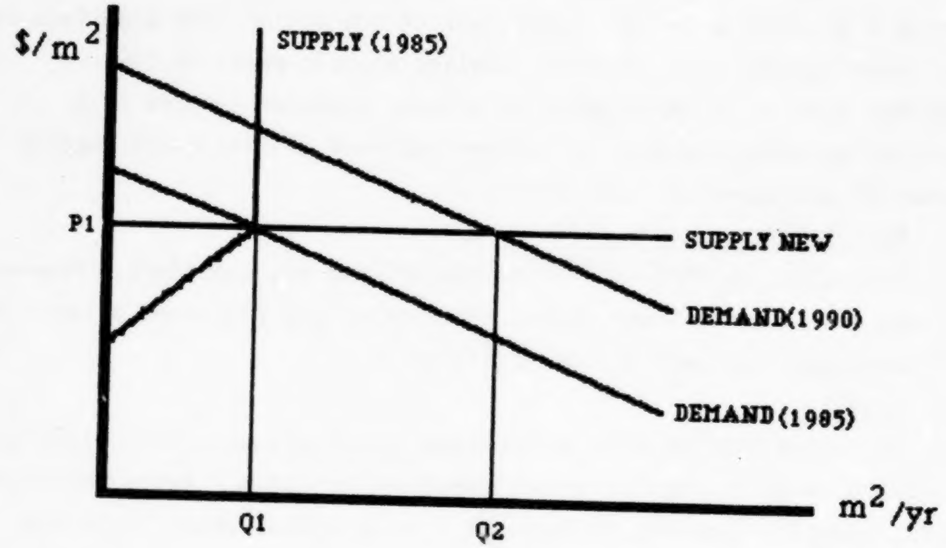


Figure 9-4. Market equilibrium without NSPS.

price at which new plants will be put in production. Output Q2-Q1 represents the amount of output supplied by facilities added over the 1985-90 period.

In Figure 9-5, the total costs of production are represented by area A + B. Area A is the annual cost of production from suppliers in existence in 1985 that are still coating plastic parts in 1990. Consumer surplus is represented by area C, producer surplus by D. Equilibrium price and quantity values for each plastic parts coating submarket are shown in Table 9-10.

Market Effects of an NSPS

Typically, an NSPS will raise the ATC for new suppliers. However, in some cases it may lower costs. Both cases are discussed below. In all there are four generic possibilities.

Case 1

In Figure 9-6 the NSPS has created cost increases that result in an upward shift in supply for new suppliers as shown. Price increases to P2, quantity demanded falls to Q3. As discussed above, existing suppliers are willing to increase output beyond Q1 but are unable to do so given their plant capacity. Their output is fixed at Q1. Output from new suppliers falls from Q2 - Q1 to Q3 - Q1. New suppliers' costs fall by area F due to the reduction in their output. On the quantity still produced (Q3 - Q1), compliance costs are represented by area H. Finally, consumer benefits fall by area F + I with less output purchased. In summary, the costs of the NSPS are

Existing suppliers = 0

New suppliers = H - F

Consumers = F + I

Net costs = H - F + F + I
= H + I.

Area H is the compliance costs for the new suppliers. Area I is the net cost of the forfeited output (Q2 - Q3).

Producer surplus increases by area G; consumer surplus falls by G + H + I. Thus, the costs net of transfers are: G + H + I - G or H + I.

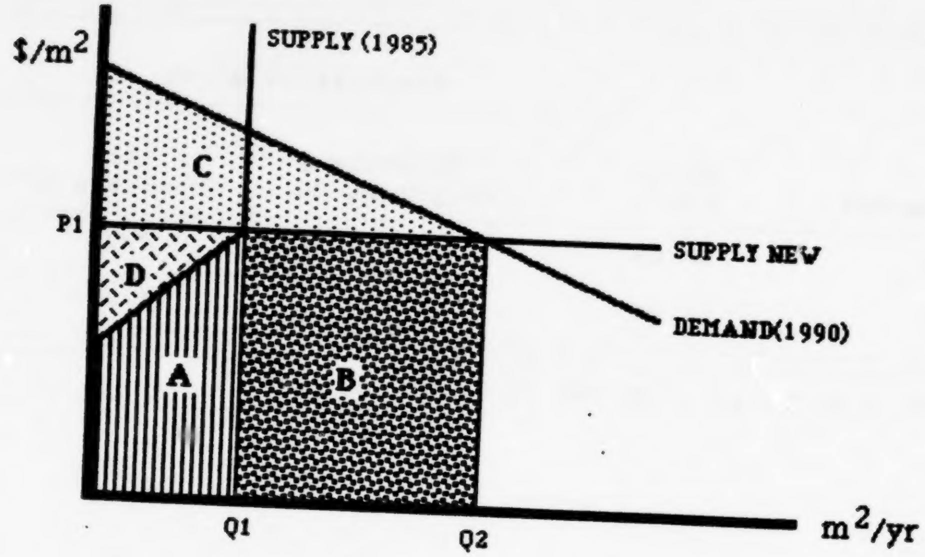


Figure 9-5. Costs and benefits without NSPS.

TABLE 9-10. EQUILIBRIUM PRICE AND QUANTITY VALUES WITHOUT AN NSPS, 1990

		Quantity $10^6 m^2/yr$	
Submarket	Price $/m^2$	Existing suppliers Q1	New suppliers Q2
A	30.69	5.20	2.79
B	14.64	10.22	5.39

Note: 1 sq meter = 10.764 sq feet.

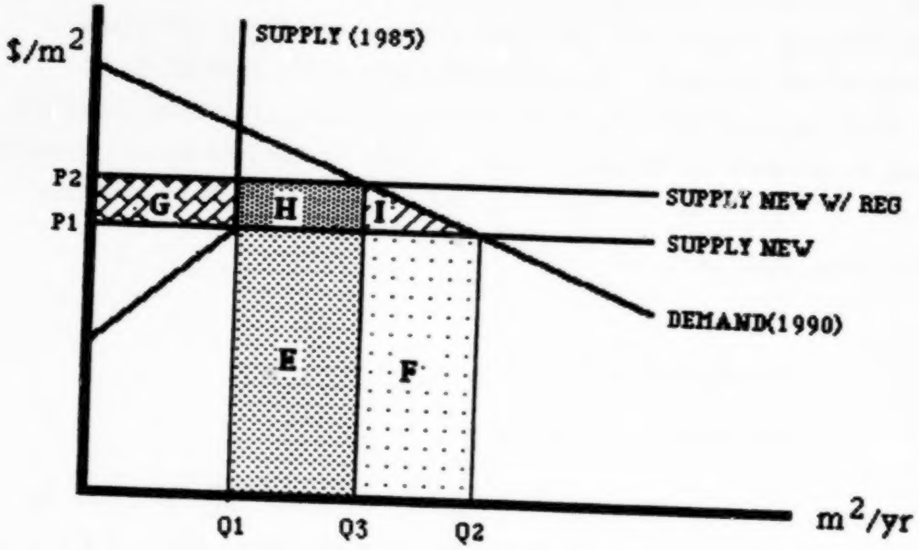


Figure 9-6. Market effects of NSPS: Case 1.

Case 2

In some cases, NSPS may raise the costs for new suppliers such that no new facilities are put in place for the analysis period. This outcome is presented here as Case 2.

As shown by Figure 9-7, the cost for new suppliers increases above the market price P3. Quantity demanded falls from Q2 to Q1. Output from new suppliers falls to zero (Q2 - Q1). Existing suppliers continue to produce at output rate Q1. Their costs fall by J. Consumer benefits fall by J + L. Summarizing the effect of the NSPS on costs

Existing suppliers = 0

New suppliers = -J

Consumers = J + L

Net costs = J + L - J
= L.

Producer surplus increases by area K; consumer surplus falls by K + L. Thus, the costs of the NSPS, net of transfers, are: K + L - K = L.

Case 3

Several of the regulatory alternatives have lower ATC than the baseline. It is generally assumed that individual firms select least-cost production techniques when adding new capacity. However, aversion to change and the risks associated with that change, especially the use of a new or emerging production technology, affects a firm's decision. Firms may have information that a different technology provides surface coating services at a lower unit cost than current installed technologies; but, the uncertainty of switching to a new technology restricts their choosing this lower-cost alternative in the immediate future. In the long-run, as new technologies become more tested and are used by more firms, the perceived risk of using a new technology is lowered and the firm will select the least-cost alternative.

In Figure 9-8 the effects of an NSPS that lowers the cost for new facilities is shown. Output increases by Q4 - Q2 to Q4. Output from

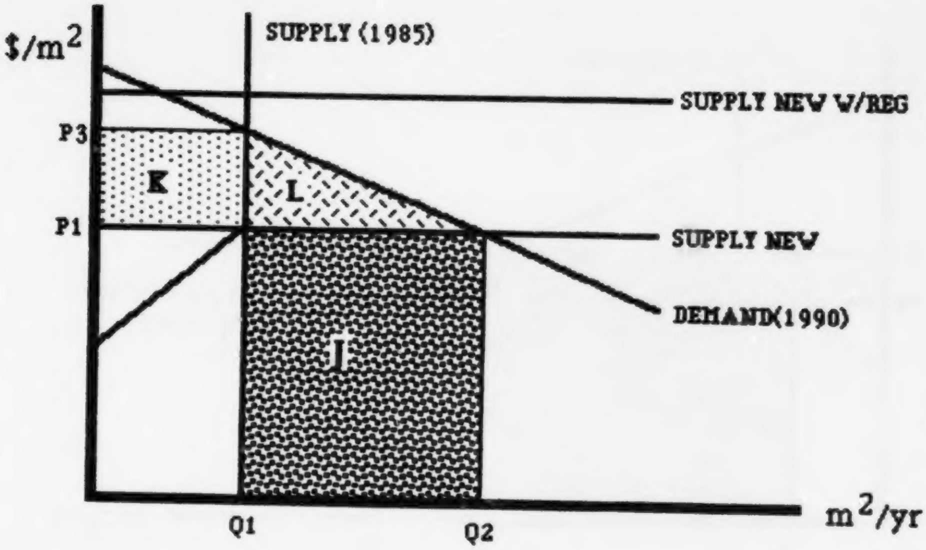


Figure 9-7. Market effects of NSPS: Case 2.

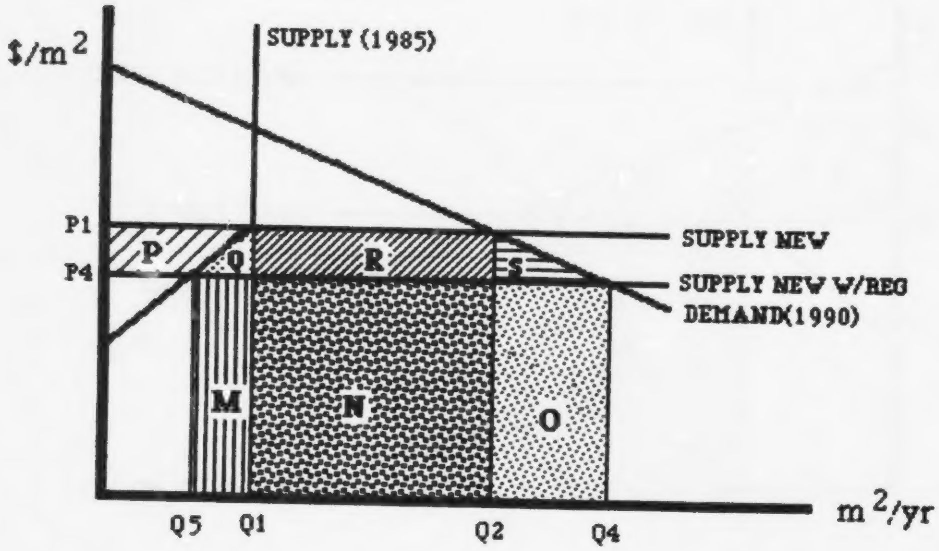


Figure 9-8. Market effects of NSPS: Case 3.

existing suppliers falls by Q1 - Q5 to Q5. Output from new suppliers increases by Q1 - Q5 + Q4 - Q2 to Q4 - Q5.

Costs for existing suppliers fall by area M + Q. For new suppliers costs increase by M - R + S. Consumer benefits increase by Q + S. In summary, costs change by

Existing suppliers = -M - Q

New suppliers = M - R + S

Consumers = -O - S

Net = -M - Q + M - R + S - O - S
= -Q - R - O.

The loss in producer surplus is P. The gain in consumer surplus is -P - Q - R - S. The cost net of transfers is -Q - R - S.

Case 4

In some cases the new production methods may be so efficient that all existing suppliers must retire their existing plant. This is the situation illustrated here.

In Figure 9-9 supply shifts downward as indicated below the lowest-cost current supplier. The NSPS results in an output increase of Q6 - Q2 to Q6. Production from existing suppliers falls by Q1 to zero. Output from new suppliers increases by Q1 + Q6 - Q2 to Q6.

Existing suppliers costs fall by T + X. Those for new suppliers increase by T + V. Consumer benefits increase by V + Z. In summary, the cost changes are

Existing suppliers = -T - X

New suppliers = T - Y + V

Consumers = -V - Z

Net cost = -T - X + T - Y + V - V - Z
= -X - Y - Z.

Looked at from the perspective of income streams, producer surplus falls by W; consumer surplus increases by W + X + Y + Z. The income effects, net of transfers, are: -W + W + X + Y + Z = X + Y + Z.

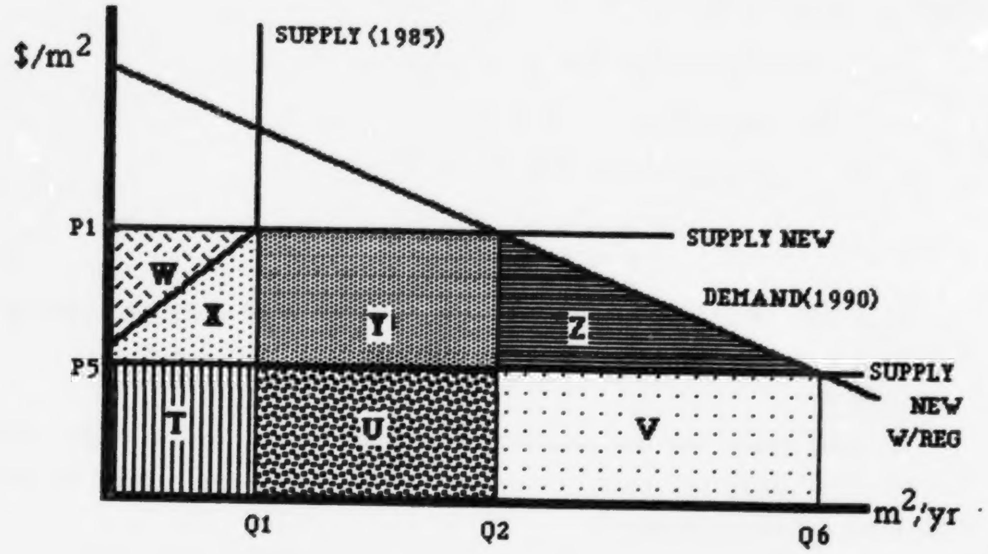


Figure 9-9. Market effects of NSPS: Case 4.

Table 9-11 shows which case applies for Market A and for Market B by type of regulatory alternative.

To project the market adjustments requires estimates of the demand and supply elasticities. For this analysis, a relatively inelastic demand of -0.25 is assumed. The demand for surface coating of plastic parts for business machines is derived from the demand for the business machines. Because the actual cost of surface coating plastic parts is not a significant cost of production for business machine producers, we assumed that demand for surface coating would be inelastic. The effect of changes in demand elasticities on the results of the analysis are reviewed in the sensitivity analysis in Section 9.2.4.

A separate supply function for existing suppliers is estimated for each market and the point elasticity of supply computed. The supply function is assumed to be linear between the baseline cost and the average variable cost for a new facility. Thus, the most efficient (least-cost) existing supplier is assumed to be a plastic parts coater recently put in place. The marginal existing supplier is assumed to have average variable cost equal to the baseline cost estimate. The estimated supply elasticities are

Market A:	22.23
Market B:	17.87 .

9.2.2 Economic Effects of Regulatory Alternatives

The economic effects discussed in this section include both direct and indirect components. Direct effects occur due to the impact of the NSPS on new surface coating facilities, e.g., an increase or decrease in the capital cost of a new facility. Indirect effects occur from the impact on existing facilities that are not directly affected by the NSPS. For example, if the NSPS requires technology that results in production cost savings, new plants will produce at lower costs than existing facilities. If these differences are significant enough, existing facilities may have to modify their production processes to remain competitive with new facilities.

Without the NSPS, many firms would still switch to the new technology required under the NSPS because of its cost-effectiveness. This

TABLE 9-11. PRICE CHANGE ANALYSIS BY REGULATORY ALTERNATIVE

	Market A	Market B
Regulatory Alternative	Type of price change	Type of price change
I-25	Baseline	Baseline
II-25	1	1
III-25	1	1
IV-25	1	1
V-25	3	3
VI-25	1	1
VII-25	1	1
VIII-25	4	4
IX-25	1	1
X-25	4	3
XI-25	4	3
XII-25	1	1
XIII-25	1	3
XIV-25	1	1
XV-25	1	1
XVI-25	1	1
I-25/40	4	4
II-25/40	3	3
III-25/40	4	3
IV-25/40	1	3
V-25/40	4	4
VI-25/40	3	3
VII-25/40	4	3
VIII-25/40	4	4
IX-25/40	1	3
X-25/40	4	4
XI-25/40	4	4
XII-25/40	4	4
XIII-25/40	1	4
XIV-25/40	3	3
XV-25/40	4	3
XVI-25/40	1	3

Case 1: $P_B < P_N \leq P_E$

Case 2: $P_E < P_N$

Case 3: $P_{AVC} < P_N < P_B$

Case 4: $P_N < P_{AVC} < P_B$

where:

P_B = Baseline price, no NSPS.

P_N = Price after NSPS.

P_E = Equilibrium price if NSPS increases costs for new suppliers and demand shift to 1990 quantities (\$56.62/m² for Market A; \$26.86/m² for Market B).

P_{AVC} = Average variable cost for the newest existing plant (\$29.30/m² for Market A and \$13.82/m² for Market B).

analysis assumes that firms would not have switched to the VOC-reducing technologies in 1990. Consequently, it represents the maximum effects that may occur as a result of the NSPS.

9.2.2.1 Price and Quantity Effects. The major economic effects of the regulatory alternatives are presented in this section. The year of analysis is 1990, 5 years from the anticipated proposal of an NSPS for surface coating of plastic business machine parts. These effects are short-run effects only in the sense that in 1990 some currently existing facilities will still be operating.

Changes in baseline values for the price and quantity for plastics parts surface coating services are projected for each regulatory alternative using a comparative statics approach. This approach assumes certainty in relevant markets and that market prices and quantities are determined by market forces and not by individual agents.

As noted earlier, the market for surface coating services is segmented into two equal parts: one served by type A model plants and one served by type B model plants. This segmentation assumes each market segment.is autonomous from the other; consequently, type A model plants compete only with other type A model plants. Dividing the market in this way provides a more accurate model of the actual surface coating market than does a market model characterized by a representative firm of only one size. The price and quantity effects are calculated separately for each market segment.

Table 9-12 shows the projected price and quantity effects for each regulatory alternative for each market segment and the total industry. The total industry-wide quantity effects are determined by adding the effects of the two markets--A and B.

Three of the four cases described in the methodology above are represented in Table 9-12. For regulatory alternatives that increase costs for new sources, the price effect shown is the minimum equilibrium price for existing suppliers (P3 in Figure 9-7) or the unit cost of the NSPS. The demand for surface coating is projected to fall. Output from existing suppliers will remain at current levels

TABLE 9-12. PLASTIC PARTS COATING: PRICE AND QUANTITY EFFECTS, 1990

	Market A						Market B						Total plastic parts market quantities			
			Quantity, 10^6 m^2						Quantity, 10^6 m^2				Quantity, 10^6 m^2			
Regulatory Alternative	Price, $/m²	Percent change in price	Existing suppliers	New suppliers	Total	Percent change in total quantity	Price, $/m²	Percent change in price	Existing suppliers	New suppliers	Total	Percent change in total quantity	Existing supplier	New supplier	Total	Percent change in total quantity
I-25	30.69	0.00	5.20	2.79	7.99	0.00	14.64	0.00	10.22	5.39	15.61	0.00	15.42	8.18	23.60	0.00
II-25	31.86	3.83	5.20	2.71	7.91	-0.96	15.37	4.98	10.22	5.19	15.41	-1.28	15.42	7.90	23.44	-0.68
III-25	31.24	1.80	5.20	2.75	7.95	-0.45	14.98	2.34	10.22	5.30	15.52	-0.58	15.42	8.05	23.47	-0.54
IV-25	43.44	41.58	5.20	1.96	7.16	-10.39	15.19	3.78	10.22	5.24	15.46	-0.94	15.42	7.20	23.44	-0.68
V-25	30.30	-1.27	3.74	4.28	8.01	0.32	14.40	-1.65	7.21	8.46	15.67	0.41	10.95	12.74	23.69	0.38
VI-25	31.47	2.56	5.20	2.74	7.94	-0.64	15.13	3.33	10.22	5.26	15.48	-0.83	15.42	7.99	23.44	-0.68
VII-25	30.85	0.53	5.20	2.78	7.98	-0.13	14.74	0.69	10.22	5.36	15.58	-0.17	15.42	8.14	23.56	-0.16
VIII-25	25.44	-17.08	0.00	8.33	8.33	4.27	13.80	-5.73	0.00	15.83	15.83	1.43	0.00	24.16	24.16	2.39
IX-25	43.06	40.31	5.20	1.98	7.18	-10.08	14.95	2.13	10.22	5.31	15.52	-0.53	15.42	7.29	23.47	-0.55
X-25	26.62	-13.25	0.00	8.25	8.25	3.31	14.53	-0.75	8.86	6.78	15.64	0.19	8.86	15.04	23.89	1.25
XI-25	25.99	-15.28	0.00	8.29	8.29	3.82	14.14	-3.39	4.02	11.72	15.74	0.83	4.02	20.01	24.03	1.85
XII-25	30.69	0.03	5.20	2.79	7.99	-0.01	14.64	0.03	10.22	5.39	15.61	-0.01	15.42	8.17	23.60	-0.01
XIII-25	36.24	18.12	5.20	2.43	7.63	-4.53	14.52	-0.81	8.74	6.90	15.64	0.20	13.94	9.33	23.58	-0.07
XIV-25	31.87	3.86	5.20	2.71	7.91	-0.98	15.37	5.02	10.22	5.19	15.41	-1.28	15.42	7.90	23.44	-0.68
XV-25	31.24	1.82	5.20	2.75	7.95	-0.46	14.99	2.37	10.22	5.30	15.52	-0.59	15.42	8.05	23.47	-0.55
XVI-25	43.45	41.60	5.20	1.96	7.16	-10.40	15.20	3.81	10.22	5.24	15.46	-0.96	15.42	7.20	23.44	-0.68
I-25/40	28.51	-7.09	0.00	8.13	8.13	1.77	13.68	-6.58	0.00	15.86	15.86	1.64	0.00	24.00	24.00	1.69
II-25/40	29.68	-3.26	1.43	6.63	8.05	0.82	14.41	-1.60	7.31	8.36	15.67	0.40	8.73	14.99	23.72	0.54
III-25/40	29.06	-5.30	0.00	8.10	8.10	1.32	14.02	-4.24	2.47	13.30	15.77	1.06	2.47	21.39	23.87	1.15
IV-25/40	40.58	32.23	5.20	2.14	7.35	-8.06	14.23	-2.78	5.15	10.57	15.72	0.69	10.35	12.71	23.66	0.26
V-25/40	28.24	-7.98	0.00	8.15	8.15	1.99	13.48	-7.92	0.00	15.92	15.92	1.98	0.00	24.07	24.07	1.99
VI-25/40	29.37	-4.29	0.24	7.84	8.08	1.07	14.21	-2.94	4.86	10.86	15.72	0.73	5.10	18.70	23.80	0.85
VII-25/40	28.74	-6.33	0.00	8.12	8.12	1.58	13.82	-5.58	0.03	15.80	15.83	1.40	0.03	23.91	23.94	1.46
VIII-25/40	23.19	-24.44	0.00	8.48	8.48	6.11	12.79	-12.65	0.00	16.10	16.10	3.16	0.00	24.58	24.58	4.16
IX-25/40	40.23	31.11	5.20	2.17	7.37	-7.78	14.04	-4.12	2.70	13.07	15.77	1.03	7.90	15.23	23.71	0.48
X-25/40	24.36	-20.60	0.00	8.40	8.40	5.15	13.52	-7.66	0.00	15.91	15.91	1.92	0.00	24.31	24.31	3.01
XI-25/40	23.74	-22.64	0.00	8.44	8.44	5.66	13.13	-10.31	0.00	16.01	16.01	2.58	0.00	24.45	24.45	3.62
XII-25/40	28.52	-7.07	0.00	8.13	8.13	1.77	13.68	-6.55	0.00	15.86	15.86	1.64	0.00	23.99	23.99	1.68
XIII-25/40	33.27	8.42	5.20	2.62	7.82	-2.10	13.51	-7.70	0.00	15.91	15.91	1.93	5.20	18.53	23.86	1.07
XIV-25/40	29.69	-3.24	1.46	6.60	8.05	0.81	14.41	-1.57	7.35	8.32	15.67	0.39	8.81	14.92	23.72	0.53
XV-25/40	29.06	-5.28	0.00	8.10	8.10	1.32	14.02	-4.22	2.52	13.25	15.77	1.05	2.52	21.35	23.87	1.14
XVI-25/40	40.55	32.15	5.20	2.14	7.35	-8.06	14.24	-2.75	5.20	10.52	15.71	0.69	10.40	12.66	23.66	0.25

Note: 1 sq meter = 10.764 sq feet.

due to the capacity of the existing plants. Additional output required to satisfy the demand for surface coating will be provided by new suppliers.

For regulatory alternatives that reduce costs, the price of surface coating of plastic parts is projected to fall. Output from existing facilities will decline while output from the more efficient new facilities will increase. For regulatory alternatives where the price falls below the average variable cost, when average variable cost is defined as annual operating cost divided by the amount of output from a model plant, output from existing suppliers will fall to zero. All production will come from more efficient new suppliers.

9.2.2.2 Costs. Regulatory alternative costs are projected for three market participants--existing suppliers, new suppliers, and consumers. These costs are summarized by market in Tables 9-13, 9-14, and 9-15 for the following categories:

- Existing Suppliers. They do not incur direct compliance costs because the NSPS is only applicable to new facilities. However, they may incur indirect costs as a result of adjusting to the market for surface coating services which is changed by the imposition of the NSPS. Production costs for existing suppliers will change depending on how the NSPS impacts industry price structure. If the NSPS increases prices, existing plants will produce more surface coating services at the higher price; this results in increased production costs. If the NSPS results in decreased prices, production costs for existing facilities may decline as less services are provided by existing plants and more by the lower cost new plants.

- New Suppliers. Like existing suppliers, new suppliers are similarly affected by increased or decreased prices resulting from the NSPS. In addition, new suppliers incur a compliance cost that existing suppliers do not. Depending on the direction of the price change, the compliance costs may be positive or negative. Negative compliance costs occur when the supplier, as a result of the NSPS, enjoys a decline in real resource costs of producing surface coating services.

- Consumers. Depending on the direction of the quantity change, consumers either gain or lose with the NSPS. For example, an NSPS that lowers prices induces consumers to

TABLE 9-13. PLASTIC PARTS COATING: 1990 COST FOR MARKET A, $\$10^6$/yr

Regulatory Alternative	Existing suppliers change in production cost	New suppliers change in production cost[a]	Compliance costs	Consumer costs	Total[b]
I-25 (BASELINE)	0.00	0.00	0.00	0.00	0.00
II-25	0.00	0.84	3.19	2.39	3.23
III-25	0.00	0.42	1.52	1.11	1.53
IV-25	0.00	-0.52	24.96	30.78	30.26
V-25	-44.68	44.08	-1.08	-0.77	-1.37
VI-25	0.00	0.58	-1.09	1.59	2.17
VII-25	0.00	0.13	0.45	0.33	0.45
VIII-25	-156.05	126.44	-14.61	-9.57	-39.18
IX-25	0.00	-0.19	24.51	29.69	29.49
X-25	-156.05	134.20	-11.33	-7.58	-29.43
XI-25	-156.05	130.10	-13.07	-8.65	-34.60
XII-25	0.00	0.01	0.02	0.02	0.02
XIII-25	0.00	2.38	13.48	12.11	14.49
XIV-25	0.00	0.84	3.21	2.41	3.25
XV-25	0.00	0.42	1.54	1.13	1.55
XVI-25	0.00	-0.53	24.97	30.80	30.28
I-25/40	-156.05	146.29	-6.07	-4.19	-13.96
II-25/40	-113.91	111.17	-2.79	-1.97	-4.71
III-25/40	-156.05	149.73	-4.53	-3.16	-9.48
IV-25/40	0.00	1.44	21.20	22.94	24.38
V-25/40	-156.05	144.58	-6.82	-4.70	-16.17
VI-25/40	-149.06	144.64	-3.67	-2.57	-7.00
VII-25/40	-156.05	147.76	-5.41	-3.76	-12.05
VIII-25/40	-156.05	111.05	-20.90	-13.15	-58.14
IX-25/40	0.00	1.61	20.67	22.03	23.64
X-25/40	-156.05	119.15	-17.62	-11.33	-48.22
XI-25/40	-156.05	114.87	-19.36	-12.30	-53.48
XII-25/40	-156.05	146.33	-6.05	-4.18	-13.90
XIII-25/40	0.00	1.61	6.77	5.38	6.98
XIV-25/40	-113.10	110.39	-2.77	-1.95	-4.67
XV-25/40	-156.05	149.76	-4.52	-3.15	-9.44
XVI-25/40	0.00	1.45	21.16	22.88	24.33

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[a] Change in production cost for new suppliers includes compliance cost.

[b] Total equals the algebraic sum of the changes in production cost for existing and new suppliers and the consumer costs.

TABLE 9-14. PLASTIC PARTS COATING: 1990 COST FOR MARKET B, $\$10^6$/yr

Regulatory Alternative	Existing suppliers change in production cost	New suppliers change in production cost[a]	Compliance costs	Consumer costs	Total[b]
I-25 (BASELINE)	0.00	0.00	0.00	0.00	0.00
II-25	0.00	0.94	3.79	2.92	3.86
III-25	0.00	0.48	1.81	1.35	1.83
IV-25	0.00	0.74	2.90	2.20	2.94
V-25	-43.71	42.97	-1.30	-0.93	-1.67
VI-25	0.00	0.66	2.57	1.94	2.60
VII-25	0.00	0.15	0.54	0.39	0.54
VIII-25	-145.42	139.60	-4.52	-3.18	-9.00
IX-25	0.00	0.44	1.65	1.23	1.67
X-25	-19.91	19.67	-0.59	-0.43	-0.67
XI-25	-89.17	86.83	-2.68	-1.91	-4.25
XII-25	0.00	0.01	0.03	0.02	0.03
XIII-25	-21.59	21.32	-0.64	-0.46	-0.73
XIV-25	0.00	0.95	3.81	2.94	3.88
XV-25	0.00	0.48	1.84	1.37	1.85
XVI-25	0.00	0.75	2.92	2.22	2.96
I-25/40	-145.42	138.09	-5.19	-3.64	-10.97
II-25/40	-42.32	41.62	-1.26	-0.90	-1.61
III-25/40	-110.99	107.55	-3.35	-2.37	-5.80
IV-25/40	-73.21	71.53	-2.19	-1.56	-3.24
V-25/40	-145.42	135.68	-6.25	-4.34	-14.09
VI-25/40	-77.32	75.48	-2.32	-1.65	-3.49
VII-25/40	-145.04	139.48	-4.40	-3.10	-8.66
VIII-25/40	-145.42	127.02	-9.98	-6.77	-25.17
IX-25/40	-107.78	104.53	-3.25	-2.30	-5.56
X-25/40	-145.42	136.14	-6.05	-4.21	-13.49
XI-25/40	-145.42	131.33	-8.13	-5.59	-19.68
XII-25/40	-145.42	138.13	-5.17	-3.62	-10.91
XIII-25/40	-145.42	136.07	-6.08	-4.23	-13.58
XIV-25/40	-41.64	40.96	-1.24	-0.89	-1.58
XV-25/40	-110.35	106.95	-3.33	-2.36	-5.75
XVI-25/40	-72.54	70.88	-2.17	-1.55	-3.20

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[a] Change in production cost for new suppliers includes compliance cost.

[b] Total equals the algebraic sum of the changes in production cost for existing and new suppliers and the consumer costs.

TABLE 9-15. PLASTIC PARTS COATING: 1990 COST FOR TOTAL INDUSTRY, $\$10^6$/YR

Regulatory Alternative	Existing suppliers change in production cost	New suppliers change in production cost[a]	Compliance costs	Consumer costs	Total[b]
I-25 (BASELINE)	0.00	0.00	0.00	0.00	0.00
II-25	0.00	1.78	6.98	5.31	7.09
III-25	0.00	0.89	3.33	2.46	3.35
IV-25	0.00	0.22	27.86	32.98	33.20
V-25	-88.39	87.05	-2.38	-1.71	-3.05
VI-25	0.00	1.24	1.47	3.53	4.77
VII-25	0.00	0.27	0.99	0.72	0.99
VIII-25	-301.47	266.04	-19.13	-12.76	-48.18
IX-25	0.00	0.25	26.17	30.91	31.16
X-25	-175.96	153.87	-11.92	-8.01	-30.10
XI-25	-245.22	216.93	-15.75	-10.56	-38.85
XII-25	0.00	0.01	0.05	0.04	0.05
XIII-25	-21.59	23.70	12.84	11.65	13.76
XIV-25	0.00	1.79	7.02	5.35	7.14
XV-25	0.00	0.91	3.38	2.50	3.40
XVI-25	0.00	0.22	27.89	33.02	33.24
I-25/40	-301.47	284.37	-11.26	-7.83	-24.93
II-25/40	-156.24	152.79	-4.05	-2.87	-6.32
III-25/40	-267.03	257.28	-7.88	-5.53	-15.29
IV-25/40	-73.21	72.97	19.01	21.38	21.14
V-25/40	-301.47	280.26	-13.07	-9.04	-30.26
VI-25/40	-226.38	220.12	-5.99	-4.23	-10.49
VII-25/40	-301.09	287.24	-9.82	-6.86	-20.70
VIII-25/40	-301.47	238.07	-30.88	-19.92	-83.32
IX-25/40	-107.78	106.13	17.42	19.73	18.08
X-25/40	-301.47	255.29	-23.67	-15.54	-61.72
XI-25/40	-301.47	246.20	-27.49	-17.89	-73.16
XII-25/40	-301.47	284.46	-11.22	-7.80	-24.81
XIII-25/40	-145.42	137.68	0.69	1.15	-6.60
XIV-25/40	-154.75	151.35	-4.01	-2.84	-6.24
XV-25/40	-266.39	256.71	-7.84	-5.51	-15.19
XVI-25/40	-72.54	72.34	18.99	21.33	21.13

[a] Change in production cost for new suppliers includes compliance cost.

[b] Total equals the algebraic sum of the changes in production cost for existing and new suppliers and the consumer costs.

> purchase some plastic parts coating services, thereby increasing their welfare. The dollar value of the increase in welfare is treated as a negative cost in this analysis.

As shown in Table 9-15, 17 of the regulatory alternatives reduce the cost of surface coating plastic parts while 15 of the alternatives increase cost. The net gains or losses to the market participants for each regulatory alternative are presented in Section 9.2.2.7.

9.2.2.3 Employment Effects. Changes in the production rate of surface coating services are expected to cause changes in the rates of resource utilization. Effects on the levels of employment in affected industries are particularly important. Projecting these effects is difficult because surface coating is a process and employment data for only the surface coating process are not available.

The employment effects for each market and regulatory alternative are estimated by assuming that employment effects will be directly proportional to quantity effects; i.e., a 10-percent increase in the quantity of plastic parts coated would cause a 10-percent increase in employment in the surface coating industry and vice versa. Table 9-16 presents projected changes in employment for each regulatory alternative.

Some of the regulatory alternatives reduce labor requirements. Where plastic parts coating is part of a vertically integrated process within a firm, it seems likely that many of the displaced workers would find other employment within the firm. The regulatory alternatives that lower costs and hence price would encourage additional plant construction and hence additional employment.

9.2.2.4 Foreign Trade Effects. The proposed regulation could have a significant effect on the industry. If it lowers the cost for producers, U.S. manufacturers may remain competitive in the market without having to purchase foreign components or moving production overseas. However, if the proposed regulation results in a significant increase in the cost for supplies, domestic firms may find it necessary to use cheaper foreign components or move their production overseas to remain competitive. The extent to which this occurs will depend on the relationship between the costs for surface coating services and the total cost of manufacturing plastic parts for business machines.

TABLE 9-16. EMPLOYMENT EFFECTS

Regulatory Alternative	Change in employment, percent		
	Market A	Market B	Total
I-25 (BASELINE)	0.00	0.00	0.00
II-25	-0.96	-1.25	-0.68
III-25	-0.45	-0.58	-0.54
IV-25	-10.39	-0.94	-0.68
V-25	0.32	0.41	0.38
VI-25	-0.64	-0.83	-0.68
VII-25	-0.13	-0.17	-0.16
VIII-25	4.27	1.43	2.39
IX-25	-10.08	-0.53	-0.55
X-25	3.31	0.19	1.25
XI-25	3.82	0.85	1.85
XII-25	-0.01	-0.01	-0.01
XIII-25	-4.53	0.20	-0.07
XIV-25	-0.96	-1.25	-0.68
XV-25	-0.46	-0.59	-0.55
XVI-25	-10.40	-0.95	-0.68
I-25/40	1.77	1.64	1.69
II-25/40	0.82	0.40	0.54
III-25/40	1.32	1.06	1.15
IV-25/40	-8.06	0.69	0.26
V-25/40	1.99	1.98	1.99
VI-25/40	1.07	0.73	0.85
VII-25/40	1.58	1.40	1.46
VIII-25/40	6.11	3.16	4.16
IX-25/40	-7.78	1.03	0.48
X-25/40	5.15	1.92	3.01
XI-25/40	5.66	2.58	3.62
XII-25/40	1.77	1.64	1.68
XIII-25/40	-2.10	1.93	1.07
XIV-25/40	0.81	0.39	0.53
XV-25/40	1.32	1.05	1.14
XVI-25/40	-8.04	0.69	0.25

We do not anticipate that the proposed regulation will cause significant changes in the existing trends towards more overseas production of business machines.

9.2.2.5 Plant Closures. Any changes in price will usually result in changes in sales volume. As noted earlier, if an NSPS causes the price to go above the equilibrium price (see Case 2 pp. 9-46 and 9-47) there will be no new facilities installed. Conversely, a drop in price will generate pressure to build new facilities to satisfy the increased demand. However, installation of new, low-cost units will tend to put pressure on high-cost existing plants to adopt the lower cost formulations and/or processes. This pressure will not occur until the coating formulations and equipment have been in use for some time, have passed the "demonstrated" phase, and are well on the way to becoming industry standards. It is evident that existing units can convert on a piecemeal basis as their customers' specifications change. The number of facilities that may have to convert is shown on Table 9-17. However, no significant number of closures are expected as a result of the NSPS.

9.2.2.6 Small Business Effects. The Regulatory Flexibility Act requires that special consideration be given to the impacts of all proposed regulations affecting small businesses. The Small Business Administration (SBA) sets the standards for classifying a business as small. If 20 percent of the small firms in a regulated industry will incur a significant adverse economic impact then a Regulatory Flexibility Analysis must be prepared. Criteria for determining what is a "significantly adverse economic impact" are

- Annualized compliance cost increases total costs of production by more than 5 percent.
- Annualized compliance cost as a percentage of sales for small firms is more than 10 percentage points higher than annualized compliance cost as a percentage of sales for large firms.
- Capital costs of compliance represent a significant portion of capital available to small entities, where available capital is measured by pretax cash flow minus

TABLE 9-17. FACILITIES WITH PRODUCTION OUTPUT THAT MAY BE INFLUENCED BY THE REGULATION

Regulatory Alternative	Model Plant A		Model Plant B		Total	
	Change in quantity supplied from existing facilities, 10^6 m^2/yr	Estimated number of facilities	Change in quantity supplied from existing facilities, 10^6 m^2/yr	Estimated number of facilities	Existing facilities: Due to decreased Q	Existing facilities: Due to increased Q
I-25 (BASELINE)	0.00	0	0.00	0	0	0
II-25	0.00	0	0.00	0	0	0
III-25	0.00	0	0.00	0	0	0
IV-25	0.00	0	0.00	0	0	0
V-25	-1.47	100	-3.01	16	116	0
VI-25	0.00	0	0.00	0	0	0
VII-25	0.00	0	0.00	0	0	0
VIII-25	-5.20	356	-10.22	54	410	0
IX-25	0.00	0	0.00	0	0	0
X-25	-5.20	356	-1.37	7	363	0
XI-25	-5.20	356	-6.20	33	389	0
XII-25	0.00	0	0.00	0	0	0
XIII-25	0.00	0	-1.48	8	8	0
XIV-25	0.00	0	0.00	0	0	0
XV-25	0.00	0	0.00	0	0	0
XVI-25	0.00	0	0.00	0	0	0
I-25/40	-5.20	356	-10.22	54	410	0
II-25/40	-3.77	258	-2.91	15	273	0
III-25/40	-5.20	356	-7.75	41	397	0
IV-25/40	0.00	0	-5.07	27	27	0
V-25/40	-5.20	356	-10.22	54	410	0
VI-25/40	-4.96	340	-5.36	28	368	0
VII-25/40	-5.20	356	-10.19	54	410	0
VIII-25/40	-5.20	356	-10.22	54	410	0
IX-25/40	0.00	0	-7.52	40	40	0
X-25/40	-5.20	356	-10.22	54	410	0
XI-25/40	-5.20	356	-10.22	54	410	0
XII-25/40	-5.20	356	-10.22	54	410	0
XIII-25/40	0.00	0	-10.22	54	54	0
XIV-25/40	-3.75	256	-2.87	15	271	0
XV-25/40	-5.20	356	-7.70	41	397	0
XVI-25/40	0.00	0	-5.02	27	27	0

Note: 1 sq meter = 10.764 sq feet.

annual capital expenditures. (The subtraction of capital expenditures from pretax cash flow is an attempt to model the capital cost of the regulation to an industry operating and making investment decisions as usual. To include normal capital expenditures, either out of need or expansion, as part of the industry's ability to pay, would represent a maximum, nonrelative measure of capital availability. While both methods have merit in examining different forces, we have chosen the former for this analysis.)

- The requirements of the regulation are likely to result in closures of small entities.

A large percentage of this industry consists of small businesses. In our analysis, Model Plant A represents a small unit. Model Plant C is twenty times as large and serves as a surrogate for a large company. Table 9-7 contains capital and annual operating costs for all the alternatives analyzed.

None of the regulatory alternatives under active consideration will increase total production costs more than 5 percent. Annualized compliance costs as a percentage of sales for small firms are less than 10 percentage points higher than the annualized compliance costs as a percentage of sales for large firms. Capital costs for compliance are generally a small percent of the baseline costs. In the case of Regulatory Alternative VIII-25/40, the capital costs for compliance amount to 25 percent of the baseline costs; yet the savings in production costs allow recovery of capital in a matter of months. Thus, there should be no problem in borrowing funds. Consequently, no closures because of economic hardship are anticipated. Thus, we can conclude from this that small business subject to regulation would not be disproportionately affected.

9.2.2.7 Distribution of Effects. Table 9-18 summarizes the distributional effects of the NSPS for each regulatory alternative. Existing suppliers producer surplus is the difference between what producers actually receive for their products (revenue) and the minimum they would have accepted on an all-or-nothing basis. The minimum represents their production costs. Generally, as prices increase,

TABLE 9-18. PLASTIC PARTS COATING: DISTRIBUTIONAL EFFECTS, $\$10^6$/yr

	Market A			Market B			TOTAL		
Regulatory Alternatives	Existing suppliers producer surplus changes	Demander consumer surplus changes	Net changes in welfare	Existing suppliers producer surplus changes	Demander consumer surplus changes	Net changes in welfare	Existing suppliers produce surplus changes	Demander consumer surplus changes	Net changes in welfare
I-25 (BASELINE)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
II-25	6.12	-9.35	-3.23	7.46	-11.32	-3.86	13.57	-20.66	-7.09
III-25	2.87	-4.39	-1.53	3.50	-5.33	-1.83	6.37	-9.72	-3.35
IV-25	66.37	-96.63	-30.26	5.65	-8.59	-2.94	72.02	-105.22	-33.20
V-25	-1.74	3.11	1.37	-2.10	3.78	1.67	-3.84	6.89	3.05
VI-25	4.09	-6.26	-2.17	4.99	-7.59	-2.60	9.08	-13.85	-4.77
VII-25	0.84	-1.30	-0.45	1.03	-1.57	-0.54	1.88	-2.87	-0.99
VIII-25	-3.59	42.77	39.18	-4.19	13.19	9.00	-7.78	55.96	48.18
IX-25	64.35	-93.84	-29.49	3.18	-4.85	-1.67	67.53	-98.69	-31.16
X-25	-3.59	33.02	29.43	-1.04	1.71	0.67	-4.64	34.73	30.10
XI-25	-3.59	36.19	34.60	-3.54	7.79	4.25	-7.13	45.98	38.85
XII-25	0.04	-0.07	-0.02	0.05	-0.07	-0.03	0.09	-0.14	-0.05
XIII-25	28.92	-43.41	-14.49	-1.13	1.86	0.73	27.80	-41.56	-13.76
XIV-25	6.16	-9.41	-3.25	7.50	-11.39	-3.88	13.66	-20.80	-7.14
XV-25	2.91	-4.46	-1.55	3.54	-5.40	-1.85	6.46	-9.86	-3.40
XVI-25	66.42	-96.69	-30.28	5.70	-8.66	-2.96	72.12	-105.35	-33.24
I-25/40	-3.59	17.55	13.96	-4.19	15.16	10.97	-7.78	32.71	24.93
II-25/40	-3.32	8.03	4.71	-2.05	3.65	1.61	-5.37	11.69	6.32
III-25/40	-3.59	13.08	9.48	-3.94	9.74	5.80	-7.53	22.82	15.29
IV-25/40	51.46	-75.84	-24.38	-3.12	6.37	3.24	48.33	-69.47	-21.14
V-25/40	-3.59	19.76	16.17	-4.19	18.28	14.09	-7.78	38.03	30.26
VI-25/40	-3.58	10.58	7.00	-3.24	6.73	3.49	-6.82	17.31	10.49
VII-25/40	-3.59	15.64	12.05	-4.19	12.84	8.66	-7.78	28.48	20.70
VIII-25/40	-3.59	61.74	58.14	-4.19	29.36	25.17	-7.78	91.09	83.32
IX-25/40	49.66	-73.30	-23.64	-3.89	9.46	5.56	45.76	-63.84	-18.08
X-25/40	-3.59	51.81	48.22	-4.19	17.68	13.49	-7.78	69.50	61.72
XI-25/40	-3.59	57.07	53.48	-4.19	23.86	19.68	-7.78	80.94	73.16
XII-25/40	-3.59	17.49	13.90	-4.19	15.10	10.91	-7.78	32.59	24.81
XIII-25/40	13.44	-20.42	-6.98	-4.19	17.77	13.58	9.25	-2.66	6.60
XIV-25/40	-3.31	7.98	4.67	-2.02	3.59	1.58	-5.33	11.57	6.24
XV-25/40	-3.59	13.03	9.44	-3.93	9.69	5.75	-7.52	22.72	15.19
XVI-25/40	51.33	-75.66	-24.33	-3.10	6.31	3.20	48.23	-69.35	-21.13

producers' surplus increases; conversely, as prices decrease, producers' surplus decreases.

Demanders' consumer surplus is the difference between what consumers actually pay for a given quantity of surface coating services and the maximum they could have been made to pay on an all-or-nothing basis. Consumers' surplus increases with price declines and decreases with price increases.

The algebraic sum of the changes in producers' surplus and changes in consumers' surplus provides a measure of the net change in welfare for society or, more specifically, the cost of the NSPS to society. A positive net change in welfare exclusive of any environmental benefits is associated with those regulatory alternatives that have negative costs to society. A negative net change in welfare means the costs to society are positive with implementation of the NSPS. However, these net changes do not reflect environmental benefits of regulation.

9.2.3 Cost-Effectiveness Analysis

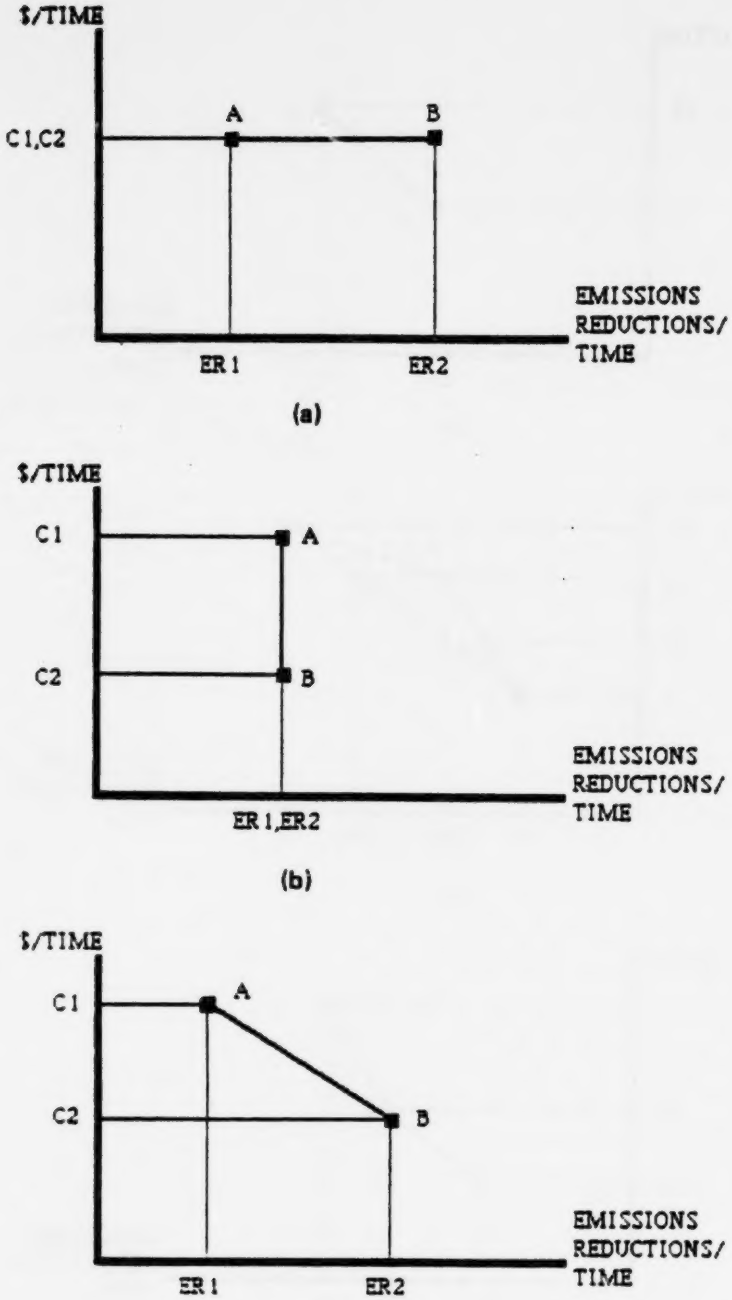
Estimates of the aggregate annual plastic parts coating emissions are compared to costs to estimate the cost-effectiveness of each regulatory alternative. The measure of cost used is the total costs of the regulation as shown in Table 9-15. The measure of effectiveness is the reduction in volatile organic compounds (VOC) emissions from plastic parts coating processes by existing and new suppliers of coating services. Table 9-19 provides the emission estimate per unit of output for existing and new technologies.

The capabilities and limitations of cost-effectiveness analysis are illustrated in Figure 9-10. In panel (a), alternatives A and B are equal in cost, yet B is more effective and is the clear choice; hence A is inferior. In panel (b), alternatives A and B are equally effective, yet B is lower in cost and is again the clear choice; again, alternative A is inferior. In panel (c), alternative A is both more costly and less effective than alternative B; it is again inferior to alternative B. In panel (d), B provides greater emissions reduction than A but only at higher costs. Neither alternative is inferior. In panel (e), three alternatives are shown. If it is possible to mix

TABLE 9-19. VOC EMISSIONS, 10^{-4} Mg/m^2

	Market A		Market B	
Regulatory Alternative	Existing Facilities	New Facilities	Existing Facilities	New Facilities
I-25 (BASELINE)	7.256	7.256	4.515	4.515
II-25	7.256	6.455	4.515	4.018
III-25	7.256	5.737	4.515	3.572
IV-25	7.256	5.559	4.515	3.460
V-25	7.256	4.990	4.515	3.110
VI-25	7.256	4.196	4.515	2.614
VII-25	7.256	3.478	4.515	2.168
VIII-25	7.256	3.943	4.515	2.458
IX-25	7.256	3.293	4.515	2.055
X-25	7.256	3.142	4.515	1.961
XI-25	7.256	2.423	4.515	1.515
XII-25	7.256	2.916	4.515	1.819
XIII-25	7.256	2.245	4.515	1.403
XIV-25	7.256	2.115	4.515	1.323
XV-25	7.256	1.396	4.515	0.877
XVI-25	7.256	1.212	4.515	0.764
I-25/40	7.256	6.216	4.515	3.868
II-25/40	7.256	5.415	4.515	3.371
III-25/40	7.256	4.696	4.515	2.926
IV-25/40	7.256	4.511	4.515	2.812
V-25/40	7.256	4.374	4.515	2.726
VI-25/40	7.256	3.573	4.515	2.230
VII-25/40	7.256	2.855	4.515	1.784
VIII-25/40	7.256	3.519	4.515	2.196
IX-25/40	7.256	2.677	4.515	1.672
X-25/40	7.256	2.725	4.515	1.700
XI-25/40	7.256	2.006	4.515	1.254
XII-25/40	7.256	2.683	4.515	1.677
XIII-25/40	7.256	1.821	4.515	1.141
XIV-25/40	7.256	1.883	4.515	1.181
XV-25/40	7.256	1.171	4.515	0.735
XVI-25/40	7.256	0.986	4.515	0.623

Note: 1 Mg = 2,204.623 lbs.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EMISSIONS REDUCTIONS/ TIME
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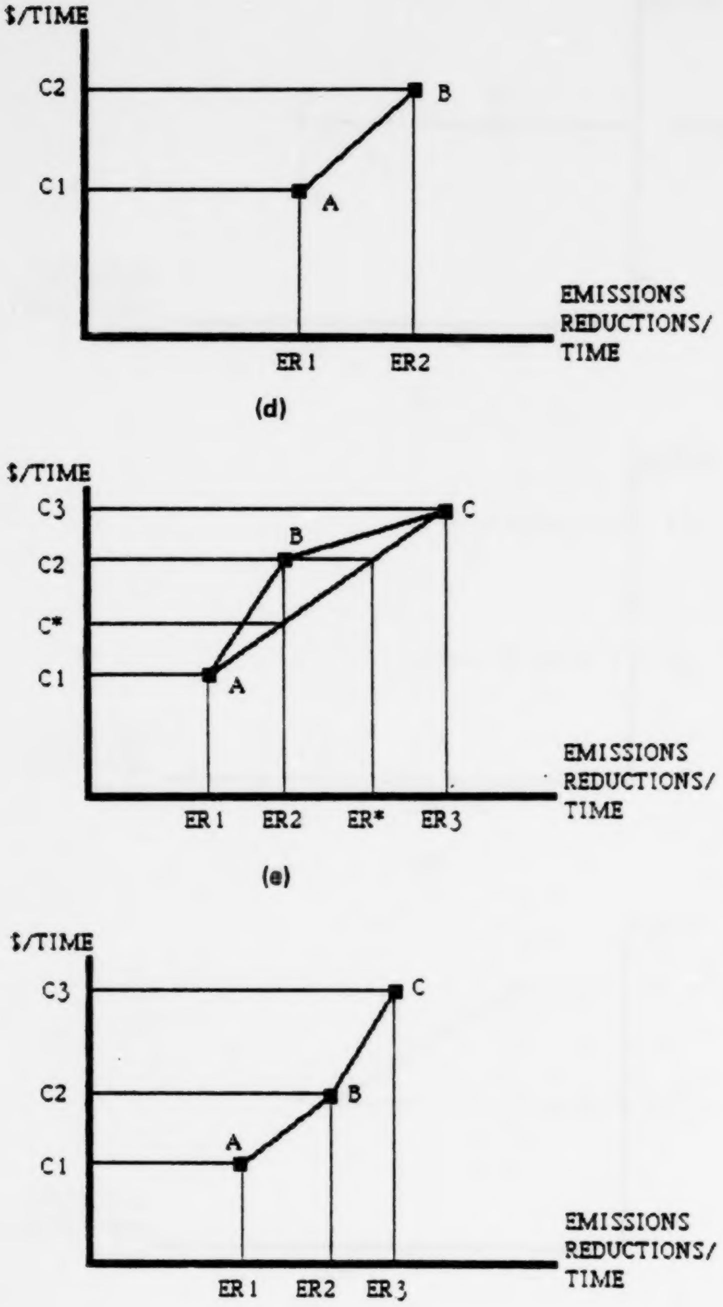
(a)

(b)

(c)

Figure 9-10. Cost-effectiveness scenarios for regulatory alternatives.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(d)

(e)

(f)

Figure 9-10 (continued)

regulatory alternatives A and C then B is inferior. This is because the same emissions reductions, ER2, obtainable with alternative B are obtainable with a mix of alternatives A and C at a cost of C*. Or, for the cost of alternative B, C2, greater emissions reduction, ER*, can be obtained by a mix of alternatives A and C; i.e., requiring some emitters to employ alternative A, others C. In such situations, B is an inferior alternative. In panel (f), three minimum cost alternatives are shown.

Table 9-20 and Table 9-21 show the total costs and emissions reductions for all regulatory alternatives for Market A and Market B respectively. Table 9-22 shows the total costs and emissions reduction for Market A and Market B combined. The alternatives are listed in order of increasing emissions reductions.

Tables 9-23 and 9-24 show the noninferior alternatives for Markets A and B, respectively. Regulatory alternatives VIII-25/40, XI-25/40, and XV-25/40 result in greater emissions reductions at less cost than all other alternatives in Market A, while alternatives VIII-25/40, XI-25/40, and XIII-25/40 are the most cost effective in Market B. For Markets A and B combined, regulatory alternatives VIII-25/40, XI-25/40, and XV-25/40 are noninferior. Table 9-25 shows that the incremental cost of VIII-25/40 is -$13,173/Mg of emission reduction. Regulatory alternatives XI-25/40 and XV-25/40 will result in a greater reduction of emissions at an additional cost of $3,604 and $90,343 respectively.

9.2.4 Sensitivity Analysis

The economic effects of the NSPS are summarized in Section 9.2.2. The numbers given are point estimates derived by using estimates and projections of all the input parameters. They can be used to compare the 32 regulatory alternatives. The most significant assumption was that for the elasticity of demand, which is derived from the demand for business machines. This analysis did not entail a rigorous development of estimates of the elasticity of demand for surface coating of plastic business machine parts. We assumed an initial elasticity of -0.25. All data discussed in Section 9.2.2 are based on this elasticity of demand.

TABLE 9-20. COST EFFECTIVENESS OF REGULATORY ALTERNATIVES FOR MARKET A

Regulatory Alternative	Emissions reduction, Mg/yr	Total cost of regulation $\$10^6$/yr	Average cost per emission reduction, \$/Mg
I-25 (BASELINE)	0.00	0.00	0.00
II-25	272.62	3.23	11853.19
III-25	444.14	1.53	3436.67
I-25/40	743.25	-13.96	-18777.48
VI-25	874.32	2.17	2484.55
IV-25	934.78	30.26	32371.00
V-25	950.92	-1.37	-1444.54
IV-25/40	1055.51	24.38	23099.96
VII-25	1056.84	0.45	427.29
II-25/40	1172.88	-4.71	-4018.94
XII-25	1209.77	0.02	19.62
IX-25	1369.79	29.49	21531.71
IX-25/40	1442.69	23.64	16384.44
XIV-25	1449.14	3.25	2245.71
XIII-25	1477.85	14.49	9804.43
XIII-25/40	1545.50	6.98	4518.56
XV-25	1638.25	1.55	946.00
XVI-25	1785.37	30.28	16957.86
XVI-25/40	1810.95	24.33	13435.11
III-25/40	1995.83	-9.48	-4752.07
V-25/40	2232.87	-16.17	-7240.66
VIII-25	2512.63	-39.18	-15592.92
VIII-25/40	2814.52	-58.14	-20658.52
VI-25/40	2824.14	-7.00	-2478.02
X-25	3203.91	-29.43	-9186.04
VII-25/40	3480.70	-12.05	-3460.66
XIV-25/40	3498.89	-4.67	-1333.52
X-25/40	3508.57	-48.22	-13744.42
XII-25/40	3615.61	-13.90	-3843.76
XI-25	3787.36	-34.60	-9134.89
XI-25/40	4104.28	-53.48	-13030.51
XV-25/40	4849.89	-9.44	-1946.49

Note: 1 Mg = 2,204.623 lbs.

TABLE 9-21. COST EFFECTIVENESS OF REGULATORY ALTERNATIVES FOR MARKET B

Regulatory Alternative	Emissions reduction, Mg/yr	Total cost of regulation $\$10^6$/yr	Average cost per emission reduction, $/Mg
I-25 (BASELINE)	0.00	0.00	0.00
II-25	345.73	3.86	11166.21
III-25	540.30	1.83	3384.43
IV-25	619.38	2.94	4744.35
I-25/40	910.40	-10.97	-12051.25
II-25/40	928.44	-1.61	-1730.68
VI-25	1058.31	2.60	2455.77
V-25	1159.49	-1.67	-1441.91
VII-25	1270.25	0.54	426.77
IX-25	1342.44	1.67	1240.73
XII-25	1452.68	0.03	17.46
X-25	1718.93	-0.67	-387.51
XIV-25	1745.93	3.88	2225.15
IV-25/40	1750.04	-3.24	-1853.67
XV-25	1968.28	1.85	941.34
XVI-25	2032.20	2.96	1458.12
III-25/40	2038.75	-5.80	-2846.29
XIII-25	2133.21	-0.73	-342.00
VI-25/40	2430.49	-3.49	-1436.94
V-25/40	2706.95	-14.09	-5204.44
XIV-25/40	2745.07	-1.58	-573.85
VIII-25	3155.71	-9.00	-2852.93
XI-25	3454.54	-4.25	-1230.02
VIII-25/40	3510.13	-25.17	-7171.11
IX-25/40	3642.46	-5.56	-1526.91
XVI-25/40	4045.94	-3.20	-791.91
VII-25/40	4215.36	-8.66	-2053.52
X-25/40	4342.80	-13.49	-3107.37
XII-25/40	4385.55	-10.91	-2488.04
XV-25/40	4934.67	-5.75	-1166.09
XI-25/40	5038.70	-19.68	-3905.06
XIII-25/40	5231.44	-13.58	-2596.26

Note: 1 Mg = 2,204.623 lbs.

TABLE 9-22. COST EFFECTIVENESS OF REGULATORY ALTERNATIVES FOR TOTAL INDUSTRY

Regulatory Alternative	Emissions reduction, Mg/yr	Total cost of regulation $\$10^6$/yr	Average cost per emission reduction, $/Mg
I-25 (BASELINE)	0.00	0.00	0.00
II-25	618.36	7.09	11469.09
III-25	984.44	3.35	3408.00
IV-25	1554.15	33.20	21360.96
I-25/40	1653.66	-24.93	-15074.43
VI-25	1932.63	4.77	2468.79
II-25/40	2101.33	-6.32	-3007.91
V-25	2110.40	-3.05	-1443.10
VII-25	2327.09	0.99	427.01
XII-25	2662.46	0.05	18.44
IX-25	2712.23	31.16	11488.50
IV-25/40	2805.56	21.14	7534.45
XIV-25	3195.07	7.14	2234.48
XV-25	3606.53	3.40	943.45
XIII-25	3611.05	13.76	3810.49
XVI-25	3817.57	33.24	8706.91
III-25/40	4034.58	-15.29	-3789.04
X-25	4922.83	-30.10	-6113.82
V-25/40	4939.81	-30.26	-6124.84
IX-25/40	5085.15	18.08	3554.67
VI-25/40	5254.63	-10.49	-1996.47
VIII-25	5668.33	-48.18	-8500.24
XVI-25/40	5856.89	21.13	3607.09
XIV-25/40	6243.96	-6.24	-999.54
VIII-25/40	6324.65	-83.32	-13173.11
XIII-25/40	6776.94	-6.60	-973.71
XI-25	7241.91	-38.85	-5364.10
VII-25/40	7696.06	-20.70	-2689.93
X-25/40	7851.36	-61.72	-7860.79
XII-25/40	8001.16	-24.81	-3100.67
XI-25/40	9142.98	-73.16	-8001.47
XV-25/40	9784.56	-15.19	-1552.91

Note: 1 Mg = 2,204.623 lbs.

TABLE 9-23. NONINFERIOR REGULATORY ALTERNATIVES FOR MARKET A

Regulatory Alternative	Emissions reduction, Mg/yr	Total cost of regulation, $\$10^6$/yr	Average cost per emission reduction, \$/Mg	Incremental cost of emission reduction,[a] \$/Mg
VIII-25/40	2814.52	-58.14	-20658.52	-20658.52
XI-25/40	4104.28	-53.48	-13030.51	3615.43
XV-25/40	4849.89	-9.44	-1946.49	59066.59

Note: 1 Mg = 2,204.623 lbs.

[a] Incremental cost of emission reduction for regulatory alternative VIII-25/40 is from baseline.

TABLE 9-24. NONINFERIOR REGULATORY ALTERNATIVES FOR MARKET B

Regulatory Alternative	Emissions reduction, Mg/yr	Total cost of regulation, $\$10^6$/yr	Average cost per emission reduction, \$/Mg	Incremental cost of emission reduction,[a] \$/Mg
VIII-25/40	3510.13	-25.17	-7171.11	-7171.11
XI-25/40	5038.70	-19.68	-3905.06	3594.96
XIII-25/40	5231.44	-13.58	-2596.26	31619.13

Note: 1 Mg = 2,204.623 lbs.

[a] Incremental cost of emission reduction for regulatory alternative VIII-25/40 is from baseline.

TABLE 9-25. NONINFERIOR REGULATORY ALTERNATIVES FOR TOTAL INDUSTRY

Regulatory Alternative	Emissions reduction, Mg/yr	Total cost of regulation, $\$10^6$/yr	Average cost per emission reduction, $/Mg	Incremental cost of emission reduction,[a] $/Mg
VIII-25/40	6324.65	-83.32	-13173.11	-13173.11
XI-25/40	9142.98	-73.16	-8001.47	3604.33
XV-25/40	9784.56	-15.19	-1552.91	90342.82

Note: 1 Mg = 2,204.623 lbs.

[a] Incremental cost of emission reduction for regulatory alternative VIII-25/40 is from baseline.

TABLE 9-26. SENSITIVITY ANALYSIS FOR DEMAND ELASTICITY

Economic effect	Alternative demand elasticity[a]		
	0	-0.125	-0.50
Percentage change in quantities supplied in 1990			
Market A	-5.76 to 11.61 (VIII-25/40) (XVI-25)	-2.88 to 5.80 (VIII-25/40) (XVI-15)	-11.61 to 5.76 (XVI-25) (VIII-25/40)
Market B	-3.07 to 1.27 (VIII-25/40) (XIV-25)	-1.53 to 0.63 (VIII-25/40) (XIV-25)	-1.27 to 3.07 (XVI-25) (VIII-25/40)
Percentage change in total costs (net welfare) in 1990			
Market A	-3.15 to 17.52 (VIII-25/40) (XVI-25)	-1.57 to 8.76 (VIII-25/40) (XVI-25)	-17.52 to 3.15 (XVI-25) (VIII-25/40)
Market B	-1.82 to 1.85 (VIII-25/40) (XIV-25)	-0.91 to 0.92 (VIII-25/40) (XIV-25)	-1.85 to 1.82 (XIV-25) (VIII-25/40)
Percentage change in net emissions produced[b]			
Market A	0.25 (XV-25/40) 2.21 (XI-25/40) 6.10 (VIII-25/40)	0.13 (XV-25/40) 1.10 (XI-15/40) 3.05 (VIII-25/40)	-0.25 (XV-25/40) -2.21 (XI-25/40) -6.10 (VIII-25/40)
Market B	0.25 (XIII-25/40) 1.00 (XI-25/40) 3.09 (VIII-25/40)	0.33 (XIII-25/40) 0.50 (XI-25/40) 1.54 (VIII-25/40)	-0..25 (XIII-25/40) -1.00 (XI-25/40) -3.09 (VIII-25/40)

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[a] Numbers show the percentage change for the given economic effect for three alternative elasticities of demand, relative to the initial elasticity of -0.25. Regulatory alternatives represented by each end of the range are given in parentheses.

[b] Only three alternatives are cost effective for Market A and Market B. The percentages shown reflect the changes for these alternatives.

To determine the responsiveness of the model to changes in the assumed elasticity of demand, we conducted a sensitivity analysis using lower and higher demand elasticities, -0.125 and -0.50, respectively. The results of this analysis are shown in Table 9-26 for three economic effects.

We also tested a demand elasticity of zero. This effectively maintains industry quantities at the baseline level of 23.6×10^6 m^2/year and assumes that consumers do not respond to changes in price. (This approach is used in Chapters 7 and 8 to estimate environmental impacts and costs.) However, the mix between output from existing and new facilities may still vary depending on the price of services provided by new facilities.

For none of the effects are the changes especially significant. For the range of demand elasticity analyzed (0.0 to -0.50), the results of our analysis are not particularly sensitive to changes in demand elasticity. For example, a 50-percent change in demand elasticity resulted in no more than an 8.76-percent change in an economic effect. Further, the engineering data on capital and annual operation costs have an estimated range of ±30 percent. Changes of less than 10 percent due to changes in demand elasticity are still within the ±30 percent band for the engineering data used to estimate the economic effects. Consequently, changes in demand elasticities between -0.125 and -0.50 do not appear to have a significant effect on the outputs of the economic effects model.

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APPENDIX A

EVOLUTION OF THE BACKGROUND INFORMATION DOCUMENT

The purpose of this study was to develop a basis for supporting proposed new source performance standards (NSPS) for the surface coating of plastic parts for business machines. To accomplish the objectives of this program, technical data were acquired on the following aspects of the surface coating of plastic parts for business machines: (1) methods of coating and types of coatings, (2) the release of VOC emissions into the atmosphere by these sources, and (3) the types and costs of demonstrated emission control technologies. The bulk of the information was gathered from the following sources:

1. Open technical literature;
2. State, regional, and local air pollution control agencies;
3. Plant visits;
4. Industry representatives; and
5. Equipment vendors.

Significant events relating to the evolution of the background information document are itemized in Table A-1.

TABLE A-1. EVOLUTION OF THE BACKGROUND INFORMATION DOCUMENT

Date	Company, consultant, or agency/location	Nature of action
3/3/83	Society of the Plastics Industry, Inc. New York, N.Y.	Letter requesting information about the surface-coated plastic parts industry.
3/7/83	IBM Corp., Research Triangle Park, N.C.	Plant visit to gather background information on the methods used to coat plastic parts for business machines.
3/11/83	Western Electric Co., Inc. New York, N.Y.	Letter requesting information about coatings applied to plastics.
3/25/83	E. I. du Pont de Nemours and Co., Wilmington, Del.	Letter requesting information about coatings applied to plastics.
3/25/83	The Sherwin Williams Co., Chicago, Ill.	Letter requesting information about coatings applied to plastics.
4/7/83	Southeastern-Kusan, Inc., Inman, S.C.	Plant visit to gather background information on the methods used to coat plastic parts for business machines.
6/17/83	U. S. Environmental Protection Agency	Memo authorizing Phase II-"Draft Development of New Source Performance Standards for Surface Coating of Plastic Parts for Business Machines."
8/5/83	Ex-Cell-O Corp., Athens, Tenn.	Letter transmitting EPA/ESED procedures for safeguarding confidential business information.
8/18/83	E/M Lubricants, Inc., West Lafayette, Ind. Eastman-Kodak Company, Rochester, N.Y. Leon Plastics, Grand Rapids, Mich. Premix, Inc., North Kingsville, Ohio Como Plastics, Columbus, Ind. Craddock Finishing, Evansville, Ind. Cashiers Plastics, Chandler, Ariz. E/M Lubricants, Inc., Denver, Colo. Applied Digital Data Systems, Inc. Hauppauge, N.Y. NCR Corp., Dayton, Ohio	Section 114 information request.
8/18/83	Ex-Cell-O Corp., Athens, Tenn.	Plant visit to gather background information on the methods used to coat plastic parts for business machines.
8/30/83	MDS-Qantel Corp., Hayward, Calif.	Plant visit to gather background information on the methods used to coat plastic parts for business machines.
8/31/83	Finishing Technology, Inc., Santa Clara, Calif.	Plant visit to gather background information on the methods used to coat plastic parts for business machines.
9/1/83	E.M.A.C., Inc., Oakland, Calif.	Plant visit to participate in an open house demonstration of the application of higher solids coatings.
1/12/84	Columbus Industries, Ashville, Ohio	Letter requesting estimated capital and annualized costs of dry filter media for model plants.

(continued)

TABLE A-1. (continued)

Date	Company, consultant, or agency/location	Nature of action
4/10/84	Texas Instruments, Inc., Houston, Tex.	Plant visit to gather background information on the use of electrostatic spray equipment for coating plastic parts for business machines.
7/11/84	Mailed to industry members, selected equipment vendors and consultants	Draft BID Chapters 3, 4, 5, and 6 and request for comment.
7/11/84	Red Spot Paint and Varnish Co., Evansville, Ind.	Letter requesting coating samples and formulation of 225 WLE 9775 and 230 WLE 10066 for Method 24 analysis.
	Emerson and Cuming, Canton, Mass.	Letter requesting coating samples and formulation of Eccocoat® CC-33W for Method 24 analysis.
	Emhart Corp., Torrance, Calif.	Letter requesting coating samples and formulation of BOSTIK 695-50-1 for Method 24 analysis.
	Graham Magnetics, Inc., North Richmond Hills, Tex.	Letter requesting coating samples and formulation of Cobaloy® P-212 Type 1AHS, Cobaloy® P-212 Type 3 (waterborne), and Cobaloy® P-212 Type 1B for Method 24 analysis.
	The Sherwin-Williams Co., Chicago, Ill.	Letter requesting coating samples and formulation of Polane® T, Polane® HST, and Polane® H for Method 24 analysis.
	Reliance Universal, Inc., Louisville, Ky.	Letter requesting coating samples and formulation of Rel-Star® for Method 24 analysis.
7/19/84	General Electric Co., Schenectady, N.Y.	Letter requesting coating samples and formulation of Emilux® 1832 for Method 24 analysis.
7/31/84	E.M.A.C., Inc., Oakland, Calif.	Letter transmitting finalized report of plant visit and requesting results and performance report of Sherwin-Williams Polane H® demonstration and general information about E.M.A.C. operations.
10/11/84	General Electric Co., Chelsea, Mass.	Letter requesting samples and formulation data of Emilux® 1832 coating for Method 24 analysis.
10/24/84	E.M.A.C., Inc., Oakland, Calif.	Site visit to attend a seminar and open-house demonstration of the application of low-VOC-content coatings.
3/7/85	Mailed to members of the Working Group	Working Group mailout.
4/10/85	CTI--E/M Lubricants, Inc., New Brighton, Minn.	Plant visit to gather background information on various methods of electromagnetic/radio frequency interference shielding and exterior coating used to coat plastic parts for business machines.
5/2/85	U. S. Environmental Protection Agency, National Air Pollution Control Techniques Advisory Committee (NAPCTAC), and industry representatives	NAPCTAC Meeting.
5/10/85	Mailed to members of the Steering Committee	Steering Committee mailout.

(continued)

TABLE A-1. (continued)

Date	Company, consultant, or agency/location	Nature of action
7/26/85	Bee Chemical Company, Lansing, Ill.	Letter requesting coating samples and formulation of B-85®, R-65®, and R-73® for Method 24 analysis.
	Graham Magnetics, Inc., North Richland Hills, Tex.	Letter requesting coating samples and formulation of Cobaloy® P-212 type 4, Cobaloy® P-212 type 4A, and reformulated Cobaloy® P-212 type 4A for Method 24 analysis.

APPENDIX B

INDEX TO ENVIRONMENTAL IMPACT CONSIDERATIONS

This appendix consists of a reference system which is cross-indexed with the October 21, 1974, Federal Register (39 FR 37419) containing the Agency guidelines concerning the preparation of environmental impact statements. This index can be used to identify sections of the document which contain data and information germane to any portion of the Federal Register guidelines.

TABLE B-1. CROSS-INDEXED REFERENCE SYSTEM TO HIGHLIGHT ENVIRONMENTAL IMPACT PORTIONS OF THE DOCUMENT

Agency guidelines for preparing regulatory action environmental impact statements (39 FR 37419)	Location within the Background Information Document
1. BACKGROUND AND SUMMARY OF REGULATORY ALTERNATIVES	
Summary of regulatory alternatives	The regulatory alternatives from which standards will be chosen for proposal are summarized in Chapter 1, Section 1.1.
Statutory basis for proposing standards	The statutory basis for proposing standards is summarized in Chapter 2, Section 2.1.
Industries affected by the regulatory alternatives	A discussion of the industries affected by the regulatory alternatives is presented in Chapter 3, Section 3.1. Further details covering the business and economic nature of the industry are presented in Chapter 9, Section 9.1.
Specific processes affected by the regulatory alternatives	The specific processes and facilities affected by the regulatory alternatives are summarized in Chapter 1, Section 1.1. A detailed technical discussion of the processes affected by the regulatory alternatives is presented in Chapter 3, Section 3.3.
2. REGULATORY ALTERNATIVES	
Control techniques	The alternative control techniques are discussed in Chapter 4.
Regulatory alternatives	The various regulatory alternatives are defined in Chapter 6, Section 6.2. A summary of the major alternatives considered is included in Chapter 1, Section 1.1.

(continued)

TABLE B-1 (continued)

Agency guidelines for preparing regulatory action environmental impact statements (39 FR 37419)	Location within the Background Information Document
3. ENVIRONMENTAL IMPACT OF THE REGULATORY ALTERNATIVES	
Primary impacts directly attributable to the regulatory alternatives	The primary impacts on mass emissions and ambient air quality due to the alternative control systems are discussed in Chapter 7, Sections 7.1, 7.2, 7.3, 7.4, and 7.5. A matrix summarizing the environmental impacts is included in Chapter 1.
Secondary or induced impacts	Secondary impacts for the various regulatory alternatives are discussed in Chapter 7, Sections 7.1, 7.2, 7.3, 7.4, and 7.5.
4. OTHER CONSIDERATIONS	A summary of the potential adverse environmental impacts associated with the regulatory alternatives is included in Chapter 1, Section 1.2, and Chapter 7. Potential socio-economic and inflationary impacts are discussed in Chapter 9, Section 9.2. Irreversible and irretrievable commitments of resources are discussed in Chapter 7, Section 7.6.

APPENDIX C

EMISSION SOURCE TEST DATA

The numerical emission limits were not developed from emission test data. Instead, they were based on the determinations of the VOC content of the coating or shielding material and the assumption that all volatile organic compounds are emitted into the atmosphere.

The solvent content of the coatings was based on data provided by coating manufacturers and is similar to that which would have been obtained using Reference Method 24. EPA has collected samples of several materials and will determine the VOC content of these samples using Reference Method 24.

APPENDIX D - EMISSION MEASUREMENT AND MONITORING

This appendix describes the measurement method experience that was gained during the emission testing portion of this study, recommended performance test procedures, and potential continuous monitoring procedures. The purposes of these descriptions are to define the methodologies used to collect the data, to recommend potential procedures to demonstrate compliance with a new source performance standard, and to discuss alternatives for monitoring either emissions or process parameters to indicate continued compliance with that standard.

D.1 EMISSION MEASUREMENT TEST PROGRAM AND METHODS

No emission source testing in the plastic parts coating industry was conducted by the Emission Standards and Engineering Division (ESED) of the Environmental Protection Agency (EPA) as part of the background support study for the new source performance standard for this industry. However, testing had been conducted earlier by ESED/EPA in similar surface coating industries, and similar test procedures would be applicable for the plastic parts coating industry.

D.1.1 Coating Analysis Testing

Extensive analysis of coating samples from other surface coating industries has been done. Coating samples were received from paint and ink manufacturers and users in the following industries: automobile and light-duty truck, metal coil, can, large appliances, pressure-sensitive tapes and labels, magnetic tape, flexible vinyl coating and polymeric coating. The coatings types included high-solvent, high-solids, waterborne, and solvent-waterborne coatings. These sample coatings encompassed the range of coatings expected in the respective industries. All the samples were analyzed using EPA Reference Method 24.

Because the expected composition of plastic parts coatings is similar to the coatings tested, Method 24 should be applicable to the plastic parts coating industry.

D.1.2 Emission Source Testing Programs

Although no plants which coat plastic parts were tested, emission tests for volatile organic compounds (VOC) were conducted at several plants in similar coating industries: automobile and light-duty truck, metal coil, can, pressure-sensitive tapes and labels, publication rotogravure, flexible vinyl coating, and polymeric coating. Because similar test procedures would be applicable to plastic parts coating, details of these test programs in other industries are discussed below.

For each individual facility that was tested, the test procedures and approaches varied somewhat due to different data needs and plant design configurations. In general, the purpose of the testing programs was to characterize the VOC emissions to the atmosphere and the control efficiency of the vapor capture and processing systems, as well as the overall solvent usage, end distribution, and material balance throughout the entire coating process. The field testing was usually much more comprehensive than the performance test procedures specified in the applicable regulations for these industries in order to evaluate various testing approaches and methods and to gather useful auxiliary information to better understand the process operation.

D.1.3 Stack Emission Testing Conducted

D.1.3.1 Testing Locations. Gas streams that were tested in other coating industries for VOC concentrations and flow rate included: inlets and outlets of vapor processing devices; exhaust streamers from mixing equipment and/or storage tanks; uncontrolled exhaust streams venting directly to the atmosphere; intermediate process streams such as hood exhausts and drying oven exhausts venting to other process units. From the concentration and flow rate results, the VOC mass emissions or mass flow rate in each stream could be calculated. Not all of these streams were tested at each plant. The streams selected for sampling at a particular plant depended on the data needs of that particular industry testing program. These gas streams were usually in vents that were suitable for conventional EPA stack emission measurement techniques, and these measurement approaches are described in this section.

If there were emissions that were not collected and vented through stacks suitable for conventional testing, then ambient VOC survey techniques had to be adopted. (An example would be open doorways or small ducts.) These nonconventional measurement techniques are described in a later section, D.1.5.

D.1.3.2 Flow Measurements. During ESED/EPA's field testing programs, Reference Methods 1, 2, 3, and 4 were used to determine the volumetric flow rate of the gas streams being sampled. Because all the stacks or ducts that were tested had diameters of at least 12 inches, Methods 1 and 2 were applicable, and alternative flow rate measurement techniques were not required. The volumetric flow rates were determined on either a dry or wet basis, depending on whether the corresponding VOC concentration method used for that site measured VOC concentrations under actual conditions (wet basis) or dry conditions.

Reference Method 1 was used to select the sampling site along the duct or stack, and to determine the number of sampling points on the cross-sectional area inside the duct. Method 2 was used to measure gas velocity. This method is based on the use of an S-type pitot tube to traverse the duct cross-section to calculate an average gas velocity. To determine the gas stream molecular weight and density, as required for Method 2, the fixed gases composition and moisture content are needed. The fixed gas composition (O_2, CO_2, CO, N_2) was usually determined by an Orsat analysis procedure detailed in Method 3. Sometimes, however, the molecular weight of the vent gases was assumed to be the same as ambient air. This was a valid assumption when no combustion sources were involved and the hydrocarbon concentrations in the stream were low. Gas stream moisture was measured following Method 4, or with a wet bulb/dry bulb approach. The less precise wet bulb/dry bulb technique was acceptable because the moisture value was not usually a crucial parameter in these tests. Also, the moisture content was not expected to differ from ambient conditions unless combustion sources were involved. The moisture content is used to adjust the molecular weight in a calculation step in Method 2, and to adjust the flow rates to a dry basis if needed. Using the duct area, the gas volumetric flow rate was then calculated.

If the flow rate in a vent was suspected to be unsteady and varied significantly during a test run, then Method 2 was modified to give an indication of the continuous flow rate. The pitot tube was left in the duct at a single representative sampling point so that any changes in the flow rate could be monitored.

D.1.3.3 Concentration Measurements. The VOC concentration in each stack was determined using one or more of the following methods:

- Reference Method 25 (M25)
- Flame Ionization Analyzer (FIA)
  - Reference Method 25A (M25A)
  - Modified calibration procedures following a more general method detailed in an EPA guideline document (GENERAL FIA)
  - Continuous measurements using direct extraction (CONT/FIA)
  - Time-Integrated bag samples (BAG/FIA)
- Reference Method 18 - Gas Chromatograph (GC) with flame ionization detector
  - Time-Integrated bag samples (BAG/GC)
  - Grab flask or syringe samples (GRAB/GC)

It should be noted that at the time of the testing, many of these methods had not been finalized, so preliminary versions were followed. However, the later changes to these methods were not significant and would not have affected the test results. Usually, two of the VOC measurement procedures were run simultaneously. This was done in order to characterize the emissions in more detail, as well as to aid in selecting an appropriate test method.

The direct extraction FIA method was used at sites which were convenient and not in hazardous areas. The direct FIA had the advantage that, with continuous measurements, minor process variations could be noted. Also, once it was set-up, it was relatively inexpensive to run it for a long time period, and thus, changes in emissions due to process variations could be easily noted.

The other methods could be used at any sampling location, including sites in explosive atmospheres or remote locations. When the time-integrated sampling methods were used (M25, BAG/FIA, BAG/GC), the sample was collected for a 45- to 60-minute time period. Because of its complex analysis procedure, the Method 25 samples had to be analyzed later in the laboratory. The integrated bag samples, however, were analyzed as soon as possible (within 24 hours) on-site by either a FIA or GC method.

The FIA's were usually calibrated with propane, although sometimes they were also calibrated with the solvent being used in the coating process, (GENERAL FIA). The GC's were calibrated with each component that was known to be in the solvent mixture being used.

The results from the different FIA sampling approaches should be equivalent, provided they are compared for the same time periods. The Method 25 results differed somewhat from the results of the FIA. The differences were probably due to the fact that the Method 25 procedure measures all carbon atoms equally, while the FIA detector has a varying response ratio for different organic compounds. The difference in results would be most pronounced when a multi-component solvent mixture is used.

The results from the two GC sampling approaches would necessarily be different because of the different sampling time periods. The results from a GC analysis are reported as concentrations for each individual compound, and thus cannot be compared directly to the FIA results. The FIA is calibrated with one compound and the total hydrocarbon concentration is reported as one number on the basis of that compound. Also, the FIA detector has a varying response ratio to different organic compounds, so again the difference in results between the GC and FIA would be most pronounced when a multi-component solvent mixture is used.

D.1.4 Liquid Solvent Material Balance Testing Conducted

The EPA did not directly conduct any long-term liquid solvent material balance tests; however, detailed records were obtained from three plants in two industries and EPA scrutinized their procedures. In all cases, the vapor recovery device was a carbon absorber. The solvent used by the plant was compared to the solvent recovered (usually on a weekly or monthly basis), in order to obtain an overall control efficiency, combining capture and recovery efficiencies. At one plant in the pressure-sensitive tapes and labels industry, the amount of solvent recovered was determined by reading the level in the solvent recovery tank at the carbon adsorber. The amount of solvent used was determined from plant purchasing, inventory, and production records. At two plants in the publication rotogravure industry, in-line meters measured the amount of solvent directed to each printing line and the recovered solvent returned to the solvent storage tank.

D.1.5 Ambient Surveys and Fugitive Emission Characterization

Ambient measurements were conducted during some test series. Open doorways and windows were monitored periodically to estimate the mass flux of VOC into and out of the coating area. The flow rate through openings was measured with a hand-held velometer or a hot-wire anemometer (4 to 9 points were sampled per opening). Concentration was measured with a portable combustible gas detector which generally conformed to Reference Method 21 specifications.

Ambient VOC concentration levels in the coating area were measured periodically during the testing period. The surveys were conducted throughout the room. If vertical stratification were suspected, surveys were conducted at various heights.

Surveys were also made of the VOC concentrations and flow rates into hood intakes above coating, embossing, or mixing operations, in order to estimate and characterize the fugitive VOC's which were drawn into the hooding exhaust stack. VOC concentration and flow measurements were made at representative spots around intake hoods as close to the intake as the physical equipment setup permitted.

Eight-hour exposure sampling was conducted during some test programs. Following a NIOSH ambient sampling procedure, ambient air samples were drawn through carbon tubes. Analysis consisted of extraction in carbon disulfide and liquid analysis by gas chromatograph for speciation of the solvent components used in the coatings.

D.1.6 Solvent Sample Analysis

Some plants mix their coatings on-site from raw materials. Samples of the solvent (or mixture of solvents) were obtained and analyzed for speciation by direct injection into a gas chromatograph. The results from these analyses indicated whether the solvent (or solvent mixture) being used matched the plant's formulation data.

Samples of recovered solvent from carbon adsorbers were also obtained and analyzed in order to compare the composition of the recovered solvent to that of the new solvent.

D.1.7 Wastewater Sample Analysis

If the solvents being used were miscible in water, then the recovered solvent from a steam-generated carbon adsorber was mixed with water and was separated in a distillation step. Wastewater samples were collected from various points in the carbon adsorption/distillation system. The water samples were analyzed for compound speciation and total organic carbon using standard laboratory water analysis procedures.

The results from this determination were used to characterize the operation of the carbon adsorber and applied to the solvent material balance calculations.

D.1.8 Product Sample Analysis

Product samples were collected and analyzed for residual solvent content in two industries. The results from this determination were applied to the solvent material balance calculations. In general, the results from the residual solvent content analyses were unreliable, and the small number of samples taken may not have been representative. Thus, the results were only viewed as general background or indicators.

In the pressure sensitive tapes and labels industry, final tape samples were collected and analyzed for residual solvent, using ASTM F 151-72 "Standard Test Method for Residual Solvents in Flexible Barrier Material." This method only provided an index for comparing solvent levels and was inappropriate for the true measurement of the mass of residual solvent.

In the flexible vinyl printing and coating industry, product samples of the vinyl wallcovering were obtained before and after the embosser and analyzed for solvent content. The test procedure was an adaptation of NIOSH ambient carbon tube measurement techniques. The product samples were put in a heated container and air was drawn across the container and then through a carbon tube, which collected the organics. The carbon tubes were analyzed for compound speciation by a gas chromatograph, in the same manner as ambient sample carbon tubes. This product sampling and analysis was a preliminary test procedure. The results were in a lower range than expected, but there is no way to independently verify the results.

D.2 PERFORMANCE TEST METHODS

Many different approaches, test methods, and test procedures can be used to characterize volatile organic compound (VOC) emissions from industrial surface coating facilities. The particular combination of measurement methods and procedures to be used depends upon the format of the standard and test procedures specified in the applicable regulation.

General testing approaches are:

1. Analysis of coatings.
2. Direct measurement of emissions to the atmosphere from stacks.
3. Determination of vapor processing device efficiency.
4. Determination of vapor capture system efficiency.
5. Determination of overall control efficiency based on liquid solvent material balance.
6. Survey of fugitive emissions.

D.2.1 Performance Testing of Coatings

D.2.1.1 Analysis of Coatings

Recommended Method. EPA Reference Method 24 is the recommended method for the analysis of coatings. This method combines several American Society of Testing and Materials (ASTM) standard methods to determine the volatile matter content, water content, density, volume solids, and weight solids of inks and related surface coatings. These parameter values are combined to calculate the VOC content of a coating in the units specified in the applicable regulation.

Reference Method 24A is similar in principle to Method 24, but some of the analytical steps are slightly different and the results would differ. It was developed specifically for publication rotogravure printing inks and contains specific analytical steps which were already widely used in that industry. Thus, Reference Method 24A is not recommended for analysis of coatings for plastic parts.

Volatile Matter Content (W_v). The total volatile content of a coating is determined by using ASTM D 2369-81, "Standard Test Method for Volatile Content of Coatings." This procedure is applied to both aqueous and nonaqueous coatings. The result from this procedure is the volatile content of a coating as a weight fraction.

Water Content(W_w). There are two acceptable procedures for determining the water content of a coating: (1) ASTM D 3792-80, "Standard

Test Method for Water Content of Water-Reducible Paints by Direct Injection into a Gas Chromatograph," and (2) ASTM D 4017-81, "Standard Test Method for Water in Paints and Paint Materials by the Karl Fischer Titration Method." This procedure is applied only to aqueous coatings. The result is the water content as a weight fraction.

Organic Content (W_O). The volatile organic content of a coating (as a weight fraction) is not determined directly. Instead, it is determined indirectly by substraction from the total volatile content and the water content values.

$$W_O = W_V - W_W$$

Solids Content (W_S). The solids content of a coating (as a weight fraction) is also determined indirectly using the previously determined values:

$$W_S = 1 - W_V = 1 - W_O - W_W$$

Volume Solids (V_S). There is no reliable, accurate analytical procedure that is generally applicable to determine the volume solids of a coating. Instead, the solids content (as a volume fraction) is calculated using the manufacturer's formulation data.

Coating Density (D_C). The density of coating is determined using the procedure in ASTM D 1475-60 (Reapproved 1980), "Standard Test Method for Density of Paint, Varnish, Lacquer, and Related Products."

Cost. The estimated cost of analysis per coating sample is: $50 for the total volatile matter content procedure; $100 for the water content determination; and $25 for the density determination. Because the testing equipment is standard laboratory apparatus, no additional purchasing costs are expected.

Adjustments. If negligibly photochemically reactive solvents are used in the coatings, then standard gas chromatographic techniques approved by the Administrator may be used to identify and quantify these solvents. The results of Reference Method 24 may be adjusted to subtract these solvents from the measured VOC content.

D.2.1.2 Sampling and Handling of Coatings. For Method 24 analysis of a coating, a 1-liter sample should be obtained and placed in a 1-liter container. The head-space in the container should be as small as possible so that organics in the coating do not evaporate and escape detection. The coating sample should be taken at a place that is representative of the coating being applied. Alternatively, the coating may be sampled in the mixing or storage area while separate records are kept of dilution solvent being added at the coating heads. Some plastic parts coatings have an ingredient (usually a resin) that cause the coating to "set" within a short time period. Samples of these coatings need to be taken before the "setting agent" has been added. Two- or three-component coatings may require separate sampling and analysis of each component.

The coating sample should be protected from direct sunlight, extreme heat or cold, and agitation. There is no limitation given in Method 24 for the length of time between sampling and analysis.

D.2.1.3 Weighted Average VOC Content of Coatings. If a plant uses all low-solvent coatings (as specified in the applicable regulation), then each coating simply needs to be analyzed following Method 24. However, if a plant uses a combination of low-and high-solvent coatings, the weighted average VOC content of all the coatings used over a specified time period needs to be determined. Depending on the format of the standard, the average is weighted by the volume or mass of coating solids.

In addition to the Method 24 formulation information, the amount of each coating used must be determined. The EPA has no independent test procedure to determine the amount of coating used, and instead it is recommended that plant inventory and usage records be relied upon. Most plants already keep detailed records of amounts of coatings used. Thus, no additional effort or cost is expected to be required to attain coating usage.

D.2.2 Stack Emission Testing

D.2.2.1 Testing Locations. Stack emission testing techniques would be needed to measure the VOC concentration and gas flow rate in stacks and ducts such as: inlets and outlets of vapor processing devices; exhaust streams from mixing equipment and/or storage tanks; uncontrolled exhaust streams venting directly to the atmosphere; intermediate process streams such as hood exhausts and drying oven exhausts venting to other process units. The particular streams to be measured depends upon the applicable regulation.

D.2.2.2 Use of Test Results. The results from the VOC concentration measurement and flow rate measurement can be combined and used in many ways. If a regulation is on a concentration basis, then only VOC concentration measurement is needed and the result can be used directly. If the regulation is on a mass emission basis (i.e., mass emitted per unit of production; or mass emitted per unit of time), then the concentration and flow rate results are combined to calculate the mass flow rate. If the regulation is on an efficiency basis, then mass flow rate is determined for each of the streams being compared and the efficiency is calculated straightforwardly.

The performance test procedure in the applicable regulation will define the test length and the conditions under which testing is acceptable, as well as the way the reference test method measurements are combined to attain the final result.

D.2.2.3 Overall Control Efficiency. Performance test methods and procedures are used to determine the overall control efficiency of the add-on pollution control system. The add-on control system is composed of two parts: a vapor capture system, and a vapor processing device (carbon adsorber, condensor, or incinerator). The control efficiency of each component is determined separately and the overall control efficiency is the product of the capture system and processing device efficiencies. (Note: This measured overall control efficiency will not reflect control or emission reduction due to process and operational changes)

D.2.2.4 Processing Device Efficiency. The three types of processing devices that are expected to be used in the plastic parts coating industry are carbon adsorbers, condensors, and incinerators. The test procedure to determine efficiency is the same for each control technology.

To determine the efficiency of the emission processing device, the VOC mass flow rate in the inlet and outlet gas streams must be determined. To determine the mass of VOC in a gas stream, both the concentration and flow rate must be measured. The recommended methods and the reason for their selection are discussed later in sections D.2.2.7 and D.2.2.8.

D.2.2.5 Capture System Efficiency. The efficiency of the vapor capture system is defined as the ratio of the mass of gaseous VOC emissions directed to the vapor processing device to the total mass of gaseous VOC emissions from the plastic parts coating line. The mass of VOC in each applicable vent is determined by measuring the concentration and the flow rate using standard EPA test methods. The recommended methods and the reason for their selection are discussed later in sections D.2.2.7 and D.2.2.8.

In order to determine capture efficiency, all fugitive VOC emissions from the coating area must be captured and vented through stacks suitable for testing. Furthermore, the coating line being tested should be isolated from any fugitive VOC emissions originating from other sources. All doors and other openings through which fugitive VOC emissions might escape would be closed.

One way to isolate the coating line from other VOC emission sources and to capture and vent all fugitive emissions from the coating line is to construct a temporary enclosure with a separate vent around those portions of the coating line (e.g. flash-off area) where fugitive emissions normally occur. The temporary enclosure should be ventilated at a rate proportional to that of the building in which the enclosure is housed in order to duplicate closely the normal emissions profile. Although this method of measuring capture efficiency may not produce conditions identical to normal operation, the rate of generation of "fugitive" emissions within the temporary enclosure will tend to be lower than without the enclosure. The enclosure walls will reduce cross drafts resulting in a conservatively high estimate of capture efficiency.

Instead of requiring a performance test, a regulation may require a specific equipment configuration in order to ensure a high capture efficiency. For example, the applicable regulation may specify a total enclosure around the coater or sealed lids and a closed venting system for coating mix equipment. To ensure that these equipment specifications are met, visible inspections or Method 21 leak detection surveys can be conducted. However, ESED/EPA has no experience using Method 21 for detecting such leaks in the surface coating industries, and thus cannot recommend a leak concentration level to be used in evaluating the performance of various pieces of capture equipment.

D.2.2.6 Stack Emission Testing - Time and Cost. The length of a performance test is specified in the applicable regulation and is selected to be representative for the industry and process being tested. The length of a performance test should be selected to be long enough so to account for variability in emissions due to up and down operation times, routine process problems, and different products. Also, the performance test time period should correspond to the cycles of the emission control device.

Coating line operations are intermittent; there are often long time periods between runs for cleanup, setup, and color matching, so the total length of a performance test could vary from plant to plant. In general, a performance test would consist of three to six runs, each lasting from 1/2 to 3 hours. It is estimated that for most operations, the field testing could probably be completed in 2 to 3 days (i.e., two or three 8-hour work shifts) with an extra day for setup, instrument preparation, and cleanup.

The cost of the testing varies with the length of the test and the number of vents to be tested: inlet, outlet, intermediate process, and fugitive vents. The cost to measure VOC concentration and flow rate is estimated at $6,000 to $10,000 per vent, excluding travel expenses.

D.2.2.7 Details on Gas Volumetric Flow Measurement Method.

Recommended methods. Reference Methods 1, 1A, 2, 2A, 2C, 2D, 3 and 4 are recommended as appropriate for determination of the volumetric flow rate of gas streams.

Large stacks with steady flow. Methods 1 and 2 are used in stacks with steady flow and with diameters greater than 12 inches. Reference Method 1 is used to select the sampling site, and Reference Method 2 measures the volumetric flow rate using a S-type pitot tube velocity traverse technique. Methods 3 and 4 provide fixed gases analysis and moisture content, which are used to determine the gas stream molecular weight and density in Method 2. The results are in units of standard cubic meters per hour.

Small ducts. If the duct is small (less than 12 inches diameter) then alternative flow measurement techniques will be needed using Method 2A, Method 2D, or Methods 2C and 1A. Method 2A uses an in-line turbine meter to continuously and directly measure the volumetric flow. Method 2D uses rotameters, orifice plates, anemometers, or other volume rate or pressure drop measuring devices to continuously measure the flowrate. Methods 1A and 2C (in combination) modify Methods 1 and 2 and use a small standard pitot tube tranverse technique to measure the flow in small ducts, and apply when the flow is constant and continuous.

Unsteady flow. If the flow in a large duct (greater than 12 inches diameter) is not steady or continuous, then Method 2 may be modified to continuously monitor the changing flow rate in the stack. A continuous 1-point pitot tube measurement is made at a representative location in the stack. For small ducts with unsteady flow, continuous measurement with Method 2A or 2D is recommended.

Adjustment for moisture. The results do not need to be adjusted to dry conditions (using Method 4 for moisture) if the VOC concentrations are measured in the gas stream under actual conditions; that is, if the VOC concentrations are reported as parts of VOC per million parts of actual (wet) volume (ppmv). If the concentrations are measured on a dry basis (gas chromatographic techniques or Method 25) then the volumetric flow rate must correspondingly be adjusted to a dry basis.

D.2.2.8 Details on VOC Concentration Measurement Method.

Method 25A. The recommended VOC measurement method is Reference Method 25A, "Determination of Total Gaseous Organic Concentration Using A Flame Ionization Analyzer"(FIA). This method was selected because it measures the expected solvent emissions accurately, is practical for long-term, intermittent testing, and provides a continuous record of VOC concentration. A continuous record is valuable because of coating line and control device fluctuations. Measurements that are not continuous may not give a representative indication of emissions. The coating lines in this industry may operate intermittently, and the vent concentrations may vary significantly. Continuous measurements and records are easier to use for intermittent processes, and the short-term variations in concentration can be noted. The continuous records are averaged or integrated as necessary to obtain an average result for the measurement period.

Method 25A applies to the measurement of total gaseous organic concentration of vapors consisting of alkanes, and/or arenes (aromatic hydrocarbons). The instrument is calibrated in terms of propane or another appropriate organic compound. A sample is extracted from the source through a heated sample line and glass fiber filter and routed to a flame ionization analyzer (FIA). (Provisions are included for eliminating the heated sampling line and glass fiber filter under some sampling conditions.) Results are reported as concentration equivalents of the calibration gas organic constitutent or organic carbon.

Instrument calibration is based on a single reference compound. For the plastic parts coating industry the recommended calibration compound is propane or butane. (However, if only one compound is used as the sole solvent at a plant, then that solvent could be used as the calibration compound.) As a result, the sample concentration measurements are on the basis of that reference compound and are not necessarily true hydrocarbon concentrations. The response of an FIA is proportional to carbon content for similiar compounds. Thus, on a carbon number basis, measured concentrations based on the reference compound are close to the true hydrocarbon concentrations. Also, any minor biases in the FIA concentration results are less significant if the results will be used in an efficiency calculation -- both inlet and outlet measurements are made and compared -- and biases in each measurement will tend to cancel out. For calculation of emissions on a mass basis, results would be nearly equivalent using either the concentration and molecular weight based on a reference gas or the true concentration and true average molecular weight of the hydrocarbons.

The advantage of using a single component calibration is that costly and time consuming chromatographic techniques are not required to isolate and quantify the individual compounds present. Also, propane and butane calibration gases are readily available in the concentration ranges needed for this industry.

The solvents commonly used in coatings in this industry are methyl-ethyl-ketone (MEK), xylene, toluene, glycol ethers, glycol ether acetates, and tetrahydrofuran (THF). Most plants use a mixture of different compounds for solvent. Since the solvent mixtures may vary from day to day and from plant to plant, there is no standard solvent mixture to use for calibration. Also, the individual compounds in the mixture will evaporate and be controlled at different rates, so the gaseous VOC mix in the exhaust stream is not the same mix as the original multi-component liquid solvent. Furthermore, if incineration is used, any semi-destructed gaseous compounds at the incinerator outlet will be different from the compounds in the original solvent mixture. Thus, there is no advantage in calibrating the FIA with the mixture of solvents being used.

The analysis technique using an FIA measures total hydrocarbons including methane and ethane, which are considered non-photochemically reactive, and thus not VOC's. Due to the coating solvent composition, little methane or ethane is expected in the gas streams so chromatographic analysis is not needed nor recommended to adjust the hydrocarbon results to a nonmethane, nonethane basis.

Other Methods. Three other VOC concentration measurement methods were considered (and rejected) for this application: Method 18, Method 25B, and Method 25.

Method 18. Gas chromatograph (GC) analysis on integrated bag samples following Method 18 was considered because results would be on the basis of true hydrocarbon concentrations for each compound in the solvent mixture. However, the BAG/GC sample technique is not a continuous measurement and would be cumbersome and impractical because of the length of the testing. Also, it would be costly and time consuming to calibrate for each compound, and there is little advantage or extra accuracy gained from the GC approach.

Method 25B. Method 25B, "Determination of Total Gaseous Organic Concentration Using a Nondispersive Infrared Analyzer," is identical to Method 25A except that a different instrument is used. Method 25B applies to the measurement of total gaseous organic concentration of vapor consisting primarily of alkanes. The sample is extracted as described in Method 25A and is analyzed with a nondispersive infrared analyzer (NDIR). Method 25B was not selected because NDIR analyzers do not respond as well as FIA's to all of the solvents used in this industry. Also, NDIR's are not sensitive in low concentration ranges (<50 ppmv), and the outlet concentrations from incinerators and carbon adsorbers are expected to often be below 50 ppmv.

Method 25. Method 25, "Determination of Total Gaseous Nonmethane Organics Content" was also considered. A 30- to 60-minute integrated sample is collected in a sample train, and the train is returned to the laboratory for analysis. The collected organics are converted in several analytical steps to methane and the number of carbon atoms (less methane in the original sample) is measured. Results are reported as organic carbon equivalent concentration. The Method 25 procedure is not recommended for this industry because it is awkward to use for long test periods and it takes integrated samples instead of continuously sampling and recording the concentration. Concentration variations would be masked with Method 25 time-integrated sample. Also, Method 25 is not sensitive in low concentration ranges (<50 ppmv). However, Method 25 has the advantage that it counts each carbon atom in each compound and does not have a varying response ratio for different compounds.

D.2.3 Liquid Solvent Material Balance

If a plant's vapor processing device recovers solvent (such as carbon adsorption or condensor systems) then a liquid solvent material balance approach can be used to determine the efficiency of the vapor control system. This is done by comparing the solvent used versus the solvent recovered. These values may be obtained from a plant's inventory records. The EPA has no test procedure to independently verify the plant's accounting records. However, it is recommended that the plant set-up and submit to the enforcement agency its proposed inventory accounting and record keeping system prior to any performance testing.

For this performance testing approach, the averaging time (performance test time period) usually needs to be 1 week to 1 month. This longer averaging period allows for a representative variety of coatings and tape products, as well as reducing the impact of short-term variations due to process upsets, solvent spills, and variable amounts of solvent in use in the process.

The volume of solvent recovered may be determined by measuring the level of solvent in the recovered solvent storage tank. The storage tank should have an accurate, easily readable level indicator. To improve the precision of the volume measurement, it is recommended that the recovered solvent tank have a relatively small diameter, so that small changes in volume result in greater changes in tank level. Alternatively, the solvent recovered may be measured directly by using a liquid volume meter in the solvent return line. Adjustments to the amount of solvent recovered may be needed to match the format of the applicable regulation. For example, if the regulation applies to only certain unit operations in a plant, then the contributions of other VOC sources must be subtracted from the total amount of solvent recovered.

The volume of solvent used may be determined from plant inventory and purchasing records or by measuring the level in the solvent storage tank. Alternatively, a liquid volume meter can be used to measure the amount of solvent drawn off from the solvent storage tank. Adjustments to the amount of solvent used may be needed to match the format of the applicable regulation. For example, the regulation may apply to only certain unit operations in a plant, or to only solvent applied at the coater not to solvent used for cleanup.

D.3 MONITORING SYSTEMS AND DEVICES

The purpose of monitoring is to ensure that the emission control system is being properly operated and maintained after the performance test. One can either directly monitor the regulated pollutant, or instead, monitor an operational parameter of the emission control system. The aim is to select a relatively inexpensive and simple method that will indicate that the facility is in continual compliance with the standard.

The three types of vapor processing devices that are expected to be used in the plastic parts coating industry are carbon adsorbers, condensors, and incinerators. Possible monitoring approaches and philosophy for each part of the VOC control system are discussed below.

D.3.1 Monitoring of Vapor Processing Devices

D.3.1.1 Monitoring in Units of Efficiency. There are presently no demonstrated continuous monitoring systems commercially available which monitor vapor processor operation in the units of efficiency. This monitoring would require measuring not only inlet and exhaust VOC concentrations, but also inlet and exhaust volumetric flow rates. An overall cost for a complete monitoring system is difficult to estimate due to the number of component combinations possible. The purchase and installation cost of an entire monitoring system (including VOC concentration monitors, flow measurement devices, recording devices, and automatic data reduction) is estimated to be $25,000. Operating costs are estimated at $25,000 per year. Thus, monitoring in the units of efficiency is not recommended due to the potentially high cost and lack of a demonstrated monitoring system.

D.3.1.2 Monitoring in Units of Mass Emitted. Monitoring in units of mass of VOC emitted would require concentration and flow measurements only at the exhaust location, as discussed above. This type of monitoring system has not been commercially demonstrated. The cost is estimated at $12,500 for purchase and installation plus $12,500 annually for operation, maintenance, calibration, and data reduction.

D.3.1.3 Monitoring of Exhaust VOC Concentration. Monitoring equipment is commercially available, however, to monitor the operational or process variables associated with vapor control system operation. The variable which would yield the best indication of system operation is VOC concentration at the processor outlet. Extremely accurate measurements would not be required because the purpose of the monitoring is not to determine the exact outlet emissions but rather to indicate operational and maintenance practices regarding the vapor processor. Thus, the accuracy of a FIA (Method 25A) type instrument is not needed, and less accurate, less costly instruments which use different detection principles are acceptable. Monitors for this type of continuous VOC measurements, including a continuous recorder, typically cost about $6,000 to purchase and install, and $6,000 annually to calibrate, operate, maintain, and reduce the data. To achieve representative VOC concentration measurements at the processor outlet, the concentration monitoring device should be installed in the exhaust vent at least two equivalent stack diameters from the exit point, and protected from any interferences due to wind, weather, or other processes.

The EPA does not currently have any experience with continuous monitoring of VOC exhaust concentration of vapor processing units in the magnetic tape industry. Therefore, performance specifications for the sensing instruments cannot be recommended at this time. Examples of such specifications that were developed for sulfur dioxide and nitrogen oxides continuous instrument systems can be found in Appendix B of 40 CFR 60.

D.3.1.4 Monitoring of Process Parameters. For some vapor processing systems, there may be another process parameter besides the exhaust VOC concentration which is an accurate indicator of system operation. Because control system design is constantly changing and being upgraded in this industry, all acceptable process parameters for all systems cannot be specified. Substituting the monitoring of vapor processing system process parameters for the monitoring of exhaust VOC concentration is valid and acceptable if it can be demonstrated that the value of the process parameter is an indicator of proper operation of the vapor processing system. However, a disadvantage of parameter monitoring alone is that the correlation of the parameters with the numerical emission limit is not exact. Monitoring of any such parameters would have to be approved by enforcement officials on a case-by-case basis. Parameter monitoring equipment would typically cost about $3,000 plus $3,000 annually to operate, maintain, periodically calibrate, and reduce the data into the desired format. Temperature monitoring equipment is somewhat less expensive. The cost of purchasing and installing an accurate temperature measurement device and recorder is estimated at $1,500. Operating costs, including maintenance, calibration, and data reduction, would be about $1,500 annually.

D.3.1.5 Monitoring of Carbon Adsorbers. For carbon adsorption vapor processing devices, the preferred monitoring approach is the use of a continuous VOC exhaust concentration monitor. However, as discussed above, no such general monitor has been demonstrated for the many different organic compounds encountered in this industry. Alternatively, the carbon bed temperature (after regeneration and completion of any cooling cycles), and the amount of steam used to regenerate the bed have been identified as indicators of product recovery efficiency. Temperature monitors and steam flow meters which indicate the quantity of steam used over a period of time are available.

D.3.1.6 Monitoring of Condensors. For condensor devices, the temperature of the exhaust stream has been identified as an indicator of product recovery efficiency, and condensor temperature monitors are available.

D.3.1.7 Monitoring of Incinerators. For incineration devices, the exhaust concentration is quite low and is difficult to measure accurately with the inexpensive VOC monitors. Instead, the firebox temperature has been identified and demonstrated to be a process parameter which reflects level of emissions from the device. Thus, temperature monitoring is the recommended monitoring approach for incineration control devices. Since a temperature monitor is usually included as a standard feature for incinerators, it is expected that this monitoring requirement will not incur additional costs to the plant.

D.3.1.8 Use of Monitoring Data. The use of monitoring data is the same regardless of whether the VOC outlet concentration or an operational parameter is selected to be monitored. The monitoring system should be installed and operating properly before the first performance test. Continual surveillance is achieved by comparing the monitored value of the concentration or parameter to the value which occurred during the last successful performance test, or alternatively, to a preselected value which is indicative of good operation. It is important to note that a high monitoring value does not positively confirm that the facility is out of compliance; instead, it indicates that the emission control system or the coating process is operating in a different manner than during the last successful performance test.

The averaging time for monitoring purposes should be related to the time period for the performance test.

D.3.2 Monitoring of Vapor Capture Systems

D.3.2.1 Monitoring in Units of Efficiency. Monitoring the vapor capture system in the units of efficiency would be a difficult and costly procedure. This monitoring approach would require measuring the VOC concentration and volumetric flow rate in the inlet to the vapor processing device and in each fugitive VOC vent and then combining the results to calculate an efficiency for each time period. Such a monitoring system has not been commercially demonstrated. The purchase and installation of an entire monitoring system is estimated at $12,500 per stack, with an additional $12,500 per stack per year for operation, maintenance, calibration, and data reduction. Thus, monitoring in the units of efficiency is not recommended.

D.3.2.2 Monitoring of Flow Rates. As an alternative, to monitoring efficiency, an operational parameter could be monitored instead. The key to a good capture system is maintaining proper flow rates in each vent. Monitoring equipment is commercially available which could monitor these flow rate parameters. Flow rate monitoring equipment for each vent would typically cost about $3,000 plus $3,000 annually to operate, maintain, periodically calibrate, and reduce the data into the desired format. The monitored flow rate values are then compared to the monitored value during the last successful performance test.

Proper flow rates and air distribution in a vapor capture system could also be ensured by an inspection and maintenance program, which generally would not create any additional cost burden for a plant. In that case, the additional value of information provided by flow rate monitors would probably be minimal. Routine visual inspections of the fan's operation would indicate whether or not capture efficiencies remain at the performance test level, and no formal monitoring of the air distribution system would be required.

If a total enclosure is specified in the applicable regulation to ensure proper capture, then the proper operation of the total enclosure can be monitored. Examples of monitoring devices include VOC concentration detectors inside the enclosure, pressure sensors inside the enclosure, flow rate meters in ducts, and fan amperage meters.

D.3.3 Monitoring of Overall Control System Efficiency on a Liquid Basis

If a plant uses a vapor recovery control device, the efficiency of the overall plant control (combined vapor capture and vapor recovery systems) can be monitored using a liquid material balance. (These amounts may need to be adjusted to match the format of the applicable regulation.) The amount of solvent used is compared to the amount of solvent recovered. These values are obtained from a plant's inventory records. For this monitoring approach, the averaging time or monitoring period usually needs to be 1 week to 1 month This longer averaging period is necessary to coordinate with a plant's inventory accounting system and to eliminate short-term variations due to process upsets, solvent spills, and variable amounts of solvent in use in the process.

Because most plants already keep good solvent usage and inventory records, no additional cost to the plant would be incurred for this monitoring approach.

D.3.4 Monitoring of Coatings

If a plant elects to use low-solvent content coatings in lieu of control devices, then the VOC content of the coatings should be monitored. There is no simplified way to do this. Instead, the recommended monitoring procedure is the same as the performance test: the plant must keep records of the VOC content and amount of each coating used and calculate the weighted average VOC content over the time period specified in the regulation.

D.4 TEST METHOD LIST AND REFERENCES

The EPA testing methods that are mentioned in this Appendix are listed below with their complete title and reference.

D.4.1 Reference Methods in Appendix A - 40 CFR 60

Method 1 - Sample and Velocity Traverses for Stationary Sources.

Method 2 - Determination of Stack Gas Velocity and Volumetric Flow Rate (Type S Pitot Tube).

Method 2A - Direct Measurement of Gas Volume Through Pipes and Small Ducts.

Method 3 - Gas Analysis for Carbon Dioxide, Excess Air, and Dry Molecular Weight.

Method 4 - Determination of Moisture in Stack Gases.

Method 18 - Measurement of Gaseous Organic Compound Emissions by Gas Chromatography.

Method 21 - Determination of Volatile Organic Compound Leaks.

Method 24 - Determination of Volatile Matter Content, Water Content, Density, Volume Solids, and Weight Solids of Surface Coatings.

Method 24A- Determination of Volatile Matter Content and Density of Printing Inks and Related Coatings.

Method 25 - Determination of Total Gaseous Nonmethane Organic Emissions as Carbon.

Method 25A- Determination of Total Gaseous Organic Concentration Using a Flame Ionization Analyzer.

Method 25B- Determination of Total Gaseous Organic Concentration Using a Nondispersive Infrared Analyzer.

D.4.2 Proposed Methods for Appendix A - 40 CFR 60

Method 1A - Sample and Velocity Traverses for Stationary Sources With Small Stacks or Ducts (Proposed on 10/21/83, 48 FR 48955).

Method 2C - Determination of Stack Gas Velocity and Volumetric Flow Rate From Small Stacks and Ducts (Standard Pitot Tube) (Proposed on 10/21/83, 48 FR 48956).

Method 2D - Measurement of Gas Volume Flow Rates in Small Pipes and Ducts (Proposed on 10/21/83, 48 FR 48957).

D.4.3 Other Methods

"General Measurement of Total Gaseous Organic Compound Emissions Using a Flame Ionization Analyzer," in "Measurement of Volatile Organic Compounds Supplement 1," OAQPS Guideline Series, EPA Report No. 450/3-82-019, July 1982.